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A STUDY OF GAS GANGRENE IN CIVIL SURGERY *

By JAMES H. BALDWIN, M.D.

AND

WILLIAM R. GILMOUR, M.D.

OF PHILADELPHIA, PA.

THE anærobie bacillus *aerogenes capsulatus* was isolated and fully described by Welch and Nuttal¹ in 1892, in an autopsy study of general emphysema. Frankel also described the bacillus independently in 1893, and by experimental as well as clinical studies, established it as the cause of gas gangrene. Ever since, medical literature has contained a constantly increasing number of reports concerning the lesions produced by this organism. By 1900, Welch had collected forty-six cases, in thirty of which the infection was mixed; fourteen showed pure culture of the bacillus, while in two cases no clear statement is made of the bacteriology. It is interesting to note the scope and trend of those forty-six cases. Eighteen were complications of compound fractures, seven were subsequent to gunshot wounds, and three followed hypodermic needle injections. Two cases developed after external urethrotomy, while single cases complicated removal of the appendix, operation for strangulated Littre hernia, nephrectomy, prostatic abscess, self-catheterization, and incision of submaxillary abscess. Five cases, non-traumatic in character, are listed; one after erysipelas, two cases of seeming spontaneous gangrene—questionably diabetic, primarily, and two cases without explanation. These cases in which the predisposing conditions were obscure were termed idiopathic by Greely,² who made an extensive study of such non-traumatic forms in 1916. He showed how exceedingly widespread the bacillus *perfringens* is. Achalmé found it in the blood of persons suffering from rheumatism and in the myocardium of two individuals who had died of "acute articular rheumatism." Vallen and Zaber in gangrenous suppurations of the appendix, Guyon, Albarian, Jungano in urinary abscesses; Frankel in an inflammatory swelling, while Chaillons and Bendetti found the organism in ocular infections. It is a normal inhabitant of the alimentary canal of man and many of the lower animals with distinct pathogenic abilities, and it possibly plays a part in the etiology of certain forms of diarrhoea. It would be expected that lesions of the abdominal organs, due to various pathological conditions, such as tumor, obstruction, ulceration and inevitable traumatism of abdominal surgery, would not infrequently be followed by inflammation directly caused by this bacillus. In Greely's study, nine cases

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of positive blood cultures in the living were summarized. Six proved fatal subsequently, ranging in time from a few hours to three months. Three recoveries are noted, after cholecystitis and appendiceal operations.

In the 175 cases collected from the literature up to 1915, by Simonds,³ the relative number of several types of wounds was as follows: Compound fracture, 61; lacerated wounds, 20; operation wounds, 11; gunshot wounds, 10; and hypodermic needle punctures, 9. Thus nearly as many cases of gas gangrene developed in hypodermic needle punctures and slightly more in operation wounds than in gunshot wounds. Gas gangrene was twice as frequent in lacerated wounds, six times more frequent in compound fracture cases than gunshot wounds. This refutes impression gained from war reports that gas gangrene was peculiarly incidental to gunshot wounds.

In the experiments of Bullock and Cramer,⁴ particles of wood, cloth, paper and other foreign substances after being soaked in a suspension of *B. Welchii* were introduced beneath the skin of mice with negative results. The presence of certain calcium salts aid in the production of gas gangrene. Doses of two and one-half mgm. of calcium chloride injected with a suspension of *B. Welchii* or of *Vibrien septique* never failed to produce gas gangrene in experimental animals. Calcium nitrate and calcium acetate have the same effect. Their conclusions were that the calcium salts produce at the site of injection a local change in the tissues, which lessens their defensive mechanism. Therefore we may conclude that the increased devitalization which includes both bone and soft tissue is probably an important accessory cause for the increased susceptibility of compound fracture over other wounds for the development of gas gangrene.

A clinical paper of great importance was contributed by Cramp⁵ in 1912. His observations and deductions from an extended series of cases in matters of surgical principles, treatment and prophylaxis are worthy of reiteration. For the total 187 cases collected by him, the gross mortality was 48 per cent. There were in all 50 amputations with 18 deaths and 32 recoveries, a mortality of 36 per cent. from this form of treatment. In contrast to this mortality of 36 per cent. for amputation, there were 30 cases involving the extremities, treated conservatively by free and generous incisions followed by continuous or frequent irrigations in baths, with three deaths. All three were due to complications, one from tetanus; one from secondary hemorrhage and one from mixed infection twenty days after injury. In each case the gas infection was fully under control some days before death occurred; nor could this author find a single instance where generous and free incisions were made at the outset, after which the wound was continuously irrigated or placed in a bath, that death had taken place. Three of these thirty cases were amputated at some period in their convalescence on account of destructive effects of the disease, but not to control it. There were nine other cases also treated in this conservative manner, where the infection was located upon the trunk, all but one were superficial and all but this one, which was a deep infection in the gluteal region, recovered. He was again unable to find a

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single instance of death where the infection had been limited to the tissue, external to the deep fascia which seems extremely resistant, no matter what form of treatment was emphasized. He observed a series where amputation had taken place below the limits of infection, through diseased tissues or the stump reinfected and recovery in every one resulted where the wound was opened widely, incisions made and irrigation instituted, except in one instance complicated by tetanus.

Prophylaxis is probably the most important aspect of treatment. All wounds in which great force had been exerted, and especially those contaminated by soil or dirt-covered objects, should be treated as if infected with gas bacilli. They should be left open whenever possible and given continuous irrigation. The wounds should always be so dressed that frequent inspection can readily be made. Encasements of plaster should never be made in such suspected wounds. He noted in the majority of the cases that pain out of all proportions to the trauma came on twelve to thirty hours after injury and was the first sign of trouble. This was followed by a sudden rise of temperature with marked rise in rate and weakness in pulse. Pus was seldom seen early. It appeared also that those cases described as mild were either in the incipient stage where the case is discovered early, or those cases superficial to the deep fascia. Finally gas infection once well established showed rapid progress with destruction, and appeared certain to result in death, without treatment. Such was the conception of gas gangrene infection before the outbreak of the World War considered as a mono-specific invasion usually caused by *B. Welchii*. However, workers who have since made bacteriologic studies of their material, emphasized that gangrenous invasions, following war wounds, were usually polyspecific. The findings in the cases of Weinberg and Seguin⁶ are the most carefully worked out and discussed. These authors described more numerous and more highly polyspecific infections than did other workers. This must in all probability be attributed to their technic. They used for isolation deep glucose agar shakes wherein the flora is spread out like a map and wherein relatively accurate estimates of the different organisms may be made. In Weinberg's⁶ experience *B. Welchii* or *B. perfringens* was found in nearly two-thirds of the cases of gas gangrene. These researches agree with those made previous to the war and resumed by Simonds. There was another combination of microbes which was found in the so-called classical form of gas gangrene, which is the form usually described in surgical literature, with definite constitutional and local signs. The bacillus of malignant oedema is the chief pathogenic organism in this group. Sometimes in the flora of the classic form of gas gangrene a new species was found, which Weinberg and Seguin described under the name *Bacillus oedematiens*. Its typical characteristic is the formation of a toxin which, if injected into a guinea pig, produces a special white oedema. These authors made experimental production of gas gangrene with these three main organisms. It was easier to reproduce experimentally, in animals, the toxic forms of gas gangrene with *Bacillus oedematiens*.

In the experimental toxic gas gangrene, the muscles are red and hyperæmic. The gas infiltration is more or less completely masked by a toxic œdema, which develops progressively up to the trunk. These workers are able to reproduce a mixed form of gas gangrene by injecting the experimental animals with a mixture of *B. perfringens* and *Bacillus œdematiens*. Also it was easy to reproduce a putrid strain of any given form of gas gangrene by introduction of *Bacillus sporogenes*. These French workers in bringing forward their proof for the polyspecific causes, clearly defined gas gangrene by the local and general symptoms known in general surgical literature. The local symptoms are essentially gaseous infiltration with gangrenous deterioration of the tissues, especially muscular and with a characteristically foul odor. Importance of these symptoms varies from case to case, hence the manifold clinical types. The general symptoms are constant and are marked by extensive intoxication, characterized especially by increased rapidity and extreme weakness of pulse, dyspnoea, without thoracic lesion and earthy, sometimes icteroid, color of the skin. These serious forms were carefully differentiated from a large number of gaseous infections, far less serious, not accompanied by the general phenomena described above and amenable to purely surgical intervention. These organisms were all capable of reproducing the double series of symptoms; local manifestations and general intoxication. Sacquepee found that the *B. perfringens* can reproduce the local lesions of gas gangrene, but it cannot be made to produce a potent toxin. He found the other organisms produced very active toxins and, experimentally, they produced lesions closely analogous to those observed in cases of gas gangrene in man. While *Bacillus perfringens* is found in 82 per cent. of his cases, he seems to minimize it in his writing and feels that it is the least noxious of the etiological factors.

Bacillus aerogenes is an organism of but limited virulence, however, in so far as this term indicates its ability to proliferate in the living normal tissues. In order that infection by this bacillus may become established, it is necessary that the tissues in which the microorganism is implanted be devitalized. However, in the body, *Bacillus Welchii*, once it has obtained a foothold in muscle tissue, is able to spread with extreme rapidity in consequence of its ability to destroy and devitalize contiguous muscle tissue. The organism grows well only in muscle and in the liver. Its ability to produce gas and tissue poison depends upon the presence of glycogen in the infected tissue. Wright⁷ conducted extensive experiments by which he showed that *B. Welchii* would grow most prolifically in bouillon to which potato had been added. He used platinum rust and other mechanical factors to provide something to serve as a cranny in which the microbe can get a start by concentrating its chemical effort at first upon some nidus of the medium. Wright commented upon the difficulty met with in starting the growth of cultures of the *Bacillus Welchii* in serum and the avalanche-like progress made when once such a start had been effected, and compared this to the way in which wound infections with this organism often become rapidly progressive. Bull and Pritchett⁸ demon-

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strated that the toxic products of the growth of *B. Welchii* exhibit anitgenic activities and readily give rise to the formation of active antitoxin substances. They next found that the immune serum developed possessed protective and curative properties. Their investigations in this direction indicate that the development of spores into vegetative bacilli may be prevented by protective inoculation of an antitoxic serum and also that the vegetative bacilli may be deprived of their toxic products, which appear to be the real offensive instrument. Further researches showed that the antitoxin for *B. Welchii* can be prepared from a single strain of the organism which yields under the conditions described a high titer of toxin and this antitoxin can be employed to combat infection or prevent infection by any strain whatever of the bacillus. The preferred habitat of the anærobic invaders is of interest. The notable muscle feeders are *B. Welchii* and *B. Chauvæi*. They may proliferate metastatically, the latter more than the former. Organisms of the *Vibrio* septique group may feed on muscle and they frequently do, but they show a preference for connective tissue and for serous lining. Moreover they show a remarkable facility for spreading along lymph and blood channels and their invasions are not to be controlled by incision of individual muscles as are *B. Welchii* infections. Many of the organisms of the œdematous group fail to spread rapidly from the site of entrance and act by means of the toxins that advance far before them. Some strains of *B. Novyi* may kill guinea pigs without any invasion at all, while other types such as the bacillus of Ghon and Mucha and the œdematiens strain of Joly, possess very active invasive powers. This question of virulence is a highly relative one. It is probably true that the Welch bacillus has not the toxicity of some other forms. The question of the incidence of gas infection in civil life is of interest. Von Hibler lists fifteen strains of *B. Welchii* that he isolated from human material. Of these only two could be called the direct cause of the death of the patient. Both of them were infections after injury. He lists four strains of *Vibrio* septique type isolated by himself and in three of these cases the organism was demonstrated to be the probable cause of death. He found Novy's bacillus once in a human case and it was probably the cause of death. Acquaintance with these three essential species—*Vibrio* Septique, *B. Œdematiens* and *Bacillus Perfringens*—made it possible to consider the specific serotherapy successfully. The first attempts at serotherapy were not very successful since they really aimed exclusively at the species mentioned at the beginning of the War; *B. perfringens* and *V. septique*, taking no account of a third agent of capital importance, the œdematiens. It is only by applying a specific therapy, either against all three germs or against the germ involved in each particular case, that a practical result can be reached. The preparation of the serums followed the general principles already established in bacteriology. For toxic germs it is important to prepare the animals for inoculation of the toxic products (so far indeed the antitoxin serums have proved more efficacious; such as antitetanus and antidiphtheria). Weinberg cites an experience of 191 cases treated with gas gangrene serums with 25

deaths, a proportion of 13.09 per cent. For the sake of comparison it must be remembered that in the same regions the mortality in non-treated cases was about 75 per cent. It often operated in a really striking manner for a whole number of cases in which no surgical operation was desirable. From the preventive point of view, serotherapy naturally proved itself still more powerful. Preventative treatment was applied solely in the cases of very severely wounded patients, particularly exposed to gangrene (arterial wounds, extensive shattering of the buttocks, thighs, etc.). A series of wounds of like nature, but not treated with sera, gave 7.2 per cent. of cases of gangrene, while only four cases of gangrene in 319 cases treated preventatively were observed. Kenneth Taylor⁹ also emphasized the relative weak toxicity of the *Bacillus Welchii*. He took a highly mechanistic view of the pathological process of gas gangrene. He defined it as the death of an extensive mass of muscle, due to the mechanical pressure action of gas produced from a local focus, by saprophytic bacteria. The substances from which the gas is formed are chiefly carbohydrate-containing tissue. Hence muscle is the tissue primarily involved. He felt that the organism is with rare exceptions the *bacillus aerogenes capsulatus*. He thought that the real action of the toxic principle is that of converting healthy muscle tissue adjacent to the wound into a favorable medium for growth and gas production by the bacteria. The activity of the gas bacteria is limited almost invariably to muscle; and the invasion of the subcutaneous tissue, by bacteria, is rare in man. When it occurs it is usually in the region of the scalp or scrotum, where the skin is comparatively rich in muscle tissue. Sustained pressure within a muscle mass depends on retention by intact muscle sheaths of the gas produced and by the occlusion of the avenues of escape due to the local swelling of the muscle fibres in response to the inflammatory reaction.

The disease then is essentially an infection of muscles and the connective tissue may be at first, at any rate, comparatively little affected. Moreover the spread is longitudinal rather than transverse and the infection spreads from end to end of a muscle, but may be unable to spread from one muscle to another. The affected muscle is at first dull and opaque, brick red in color and resembles cooked meat. Even at this stage it is dead, for it does not contract when pinched and does not bleed when incised. Bubbles of gas which can be pressed up and down between the fibres may be evident to the naked eye. Soon it becomes softer and diffuent, the color changing to green, brown or black. The exudate is blood-stained. Gas can be felt in the tissues over an area considerably greater in extent than those of the dead tissue. The microscopic appearance of the growing edge, as described by McNee and Dunn,¹⁰ throws a flood of light upon the spread of the disease. The first change observed is a separation of the muscle fibre from the surrounding interstitial tissue, with a clear space between fibres which McNee and Dunn considered to be filled with a toxic fluid. The fibre itself loses its shadow and stains a uniform eosin tint. At a later stage the sarcolemma disappears and finally the entire muscle fibre disintegrates and becomes gelatinous. The

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bacteria of the spreading edge are confined to the interstitial tissue and do not invade the muscle fibres at first, but at a later stage the disintegrating fibres are crowded with bacteria. It would appear therefore that the bacilli spread up and down the muscle in the interstitial tissue, preceded perhaps, by a toxic fluid which separates the muscle fibres from the interstitial tissues and kills the fibres so that they may be invaded by the bacteria. It is thus easy to understand why the spread should be longitudinal and why it should be seldom in a transverse direction. Blake, in a recent article, gives Taylor credit for improvement in treatment by the suggestions offered in his theory. For, following his teaching, the deep fascia was opened for some distance beyond the original wound. Results were improved thereby, but still better results were obtained by excision of the affected muscles throughout their entire length. It has always seemed to Blake¹¹ remarkable that the sheath of a muscle could confine the infection as it seems to, but he has demonstrated this fact and has dissected a muscle entirely, it being brick red throughout, while adjacent muscles were normal. In his study of antiseptic solutions, he found none that acted so effectively on gas gangrene, as to make its use preferable to others, with the exception of quinine, which in experimental gas gangrene showed strong inhibitory action. His impression is that Dakin's solution owes its efficiency largely to its solvent action upon the pabulum of the bacteria, but in the case of gangrene the dead tissue is so massive as to be beyond the reach of solvents. He also makes a strong plea for the sera in use at the end of the war and now, which are our chief reliance in treatment and aid in combating this terrible infection. He also cites cases where the entire process was arrested by the use of sera even without operative intervention, in cases which from their extent and character would have proven fatal without serum therapy.

Cases of anærobie invasion exclusive of tetanus, coming to necropsy in civil life, may be classified into two groups, one group is that of patients being weakened by sickness or operation, and invaded by their own intestinal bacteria. Such invasions, though they may be and frequently are polyspecific, usually have for their chief invader the Welch bacillus. But systemic or local invasions (the second group) following wound invasions, under which head comes puerperal infections, especially such invasions as have small foci, are frequently not caused by *Bacillus Welchii*, even though the latter organism may be found. The severity of tissue destruction and the presence of foreign matter has much to do with the type of invader capable of multiplying in the first few hours. Finally the resisting powers of the patient must be weighed. Binnie¹² cites the rather extensive sclerotic changes noted in the liver and kidneys of many young soldiers who were apparently in perfect health. Such latent pathological conditions may well lower the resistance of their subjects and may explain to some extent why of two similar individuals who have suffered similar wounds, have been similarly exposed to infection, and have been identically treated, one succumbs to the infection and the other overcomes it.

In 1922, Christopher,¹³ after a rather careful search in recent literature of gas gangrene, was able to report only nine cases by seven authors. All were traumatic, including one case complicating a septic criminal abortion. This report covers the time from Simond's résumé in 1915 to 1922. Despite the paucity of reported cases Christopher was inclined to the belief that gas gangrene is encountered rather frequently in civil surgery, but not reported. From 1922, the time of Christopher's paper to date, we have collected twenty-six authors writing clinical papers upon this subject, reporting 64 additional cases. Twenty-six are clearly of traumatic origin, twenty complicate obstetrical and gynecological states where the cause may be traumatic or non-traumatic, for the authors differ in their disposition of these cases. The remaining eighteen cases include those cases in which the process is caused by the subject's own intestinal organisms. This series includes eleven cases complicating gangrenous appendicitis and its sequelæ. Jennings¹⁴ finds that the evidences of intoxication due to the *B. Welchii* in the peritoneal cavity are insidious in their onset and do not differ from those which have been associated with septic peritonitis for many years. There may or may not be a rise in temperature. The pulse frequently rises, cyanosis in some degree is an early sign and increased with the severity of the case. As the case advances the pupils dilate, the skin becomes cold and clammy, while the pulse becomes thready and feeble and impalpable. Consciousness is frequently unimpaired until the last or a short period of delirium may occur. The cyanosis now becomes extreme and death supervenes. This author reports brilliant results with the tetanus-perfringens serum of Bull and Pritchett. Two cases each were associated with ruptured gastric ulcers, cholecystitis and ischio-rectal abscesses. One case complicated liver abscess.

CASE REPORTS

During this period since Christopher's report in 1922, we have found six clinical cases in the records of the Methodist Episcopal Hospital of this city and we believe other hospitals can show similar reports. We wish to report two personal cases, traumatic in character, in which we were able to follow the processes from their onset. Gas gangrene serum was used early and energetically in both cases—the wounds were treated later largely by physio-therapy while necessary auxiliary surgical procedures were employed to make cures complete. The remaining four cases have occurred upon the services of our colleagues who have kindly allowed us to put their cases in this record.

CASE I.—October 7, 1923. J. D. P., a small, poorly nourished Italian boy, aged ten, was shot with a shot gun at very close range while playing in and about the collected refuse known in the southern part of the city as the "dumps." After he fell in a dirt road by these refuse heaps he was picked up by several boys. The police were called and brought him to the accident ward of the Methodist Hospital, where emergency measures were taken for large bleeding wounds upon the anterior, inner aspect of the right and left upper thighs. Much dirt, burned portions of clothing and gun wadding were present in the wounds. These wounds were large and irregular in outline. Much skin, deep fascia and muscle were destroyed and the released muscle

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tissues bulged out of the jagged and torn wounds. The wounds were dressed, after preliminary cleansing and débridement, with dichloramine and sterile dressings: 1500 units of tetanus antitoxin were administered. He was admitted to the service of Dr. J. H. Baldwin.

Physical examination revealed a small, poorly nourished Italian boy, quite lacking in general hygiene, with carious teeth, injected pharynx and cryptic tonsils, but with no adenopathy. Chest was flat, lungs were normal, while the heart showed a soft, systolic murmur with accentuated second pulmonic sound. The abdomen was negative. The upper thighs showed the wounds noted upon admission, but bleeding was checked. There

was no odor in the wounds.

Severe pain, feeling of apprehension and marked mental alertness were noted. October 8, 1923, at 3 A.M., the temperature per rectum was 105° F. and the dressings were bloody. Upon removing those of the right thigh a few small bubbles were noticed issuing from beneath the disrupted sartorius muscle. The tissues (muscle) were markedly swollen, parchment-like and in part of gelatinous consistency. The pulse at the internal malleolus and the popliteal space was present.

Welch Bacilli were found in smears and later in pure culture in inoculated rabbit's blood. At 10.30 A.M. there was marked pain, rising temperature; rapid pulse of weak volume, and a severe generalized convulsion, lasting ten minutes. There was marked restlessness, apprehension and some degree of delirium. Discoloration through torn tissues and in the intact skin was becoming more progressive. At 12.15 P.M., 50 c.c. of commercial gas bacillus serum was given intramuscularly in the back. The peculiar characteristic odor was first noted, while many bubbles were seen to issue from beneath and around the torn and swollen muscle. Moderate quantities of very thin sero-pus accompanied the gas. Evidence of fascial necrosis was already present. At 4 P.M., within the first twenty-four hours after the injury, a second 50 c.c. tube of the gas gangrene serum was injected intramuscularly. These injections were repeated in similar



FIG. 2.—Gunshot wounds followed by gas gangrene.

manner upon the next two successive days. The extent of the process locally and the general toxæmia were seemingly checked by the first doses. After the fourth injection the patient was brighter, freer of pain and was anxious and able to take nourishment. During these days and subsequently, the left thigh wound was carefully protected and redressed lightly while the extremities and trunk were under an electric light cabinet continuously. We ordered irrigations of hydrogen peroxide every second hour. With a soft catheter, connected to a compressed gas tank, oxygen was bubbled through the depths of the wound at frequent intervals. This therapy while persisted in regularly, did not seem to change the conditions of local necrosis in any degree, and we are unable to say whether it was of any value. Four additional doses (50 c.c. each) of the gas gangrene serum were administered intramuscularly during the next seven days. Secondary invaders, hæmolytic streptococci and staphylococcus aureus were noted in the wound secretions. No *B. Welchii* were found in any subsequent bacterial studies. November 5, 1923: X-ray report showed in right thigh, a large charge of small bird-shot (middle of inner thigh). Left thigh showed only six small bird-shot.

November 28, 1923.—Under gas anæsthesia, the various sinuses in the posterior right thigh were opened and many pockets of small shot were removed. The wounds were flushed daily and physiotherapy, which had been started earlier, continued. The patient was discharged without contractures, but with one small, granulating wound. Further treatment was continued in the out-patient department and the sinus soon closed.

March 11, 1926.—The X-ray revealed six shots still in the left thigh, while many shot were scattered through the area of the old infected site in the right thigh. Patient has no contractures. General condition and hygiene improved.

CASE II.—June 19, 1925. J. F., aged ten, was brought to the Methodist Hospital giving a history of falling and injuring his right forearm while jumping from a coal car to an oil tank along the railroad right of way in South Philadelphia. Upon examination in the accident ward a compound fracture of the ulna was noted, with marked laceration along the ulnar aspect in the area of the upper and middle third of the forearm. There was much dirt ground into this deep wound, but the fragments were not protruding. The wound was cleansed, débrided, dressed with iodine and sterile gauze. Antitetanic serum was given, X-ray taken, and then the patient was permitted to go home.

The X-ray showed fracture of the ulna in the middle of the right forearm in rather poor position. There was some rotation with slight overlapping. The following day he was admitted to the hospital as the lacerated area was swollen and very painful. Free and generous incisions were made after culture of the wound secretion. *B. Welchii* was reported as positive in pure culture from inoculated rabbit. The arm was placed under an electric light cabinet and given baths in hot solutions of magnesium sulphate at regular intervals. Fifty c.c. of gas bacillus serum were given intravenously. This dosage was repeated daily, intravenously, for three days. Applications of 2 per cent. mercurochrome, baths of hot magnesium sulphate solution with the injured extremity—exposed to electric light under a cabinet were continued. The local and general signs were quickly controlled and held under control. Hæmolytic staphylococci and streptococci were found in wound secretions, subsequently.

July 11, 1925.—X-ray report shows the upper fragment of ulna resting on radius.

Cultures from this date were negative for *B. Welchii*. Patient was discharged from the hospital July 22, 1925, with sinus formation and treated in the out-patient department and X-rayed at frequent intervals. A sequestrum formed, and on March 7, 1926, he was readmitted to the hospital and operated on under ether anæsthesia. Incision was made about the sinus in which a probe had been placed. The incision was freely extended and deepened to the fusiform new bone growth. The upper wall of the involucrum was removed with a chisel and the old sequestrum was easily extracted. The wound was dressed with 5 per cent. mercurochrome and light gauze packing and redressed in the ward. Convalescence was uneventful. Function was excellent.

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CASE III.—R. T., age fifty-eight. Male. Admitted to the service of Dr. George Ross, August 12, 1922, with severe pain and marked swelling in right groin, which developed while working as a laborer, one day previously. Swelling soon appeared after the inguinal pain, which swelling became larger, more painful and intense. He had never worn a truss and never suffered a rupture before. He was rushed to the hospital and an emergency operation was performed by Dr. Calvin Smyth. Two days later, August 14, 1922, swelling and induration were noted in the operated area, with a dusky change in the color of the skin. Progressive induration was noted, extending very rapidly up the sides of the trunk and down the thighs. The clinical diagnosis of gas gangrene was made after the wound was reopened. Culture showed the bacillus of Welch. Patient died two days after the radical reopening, which included orchidectomy (right). Hydrogen peroxide locally and all forms of stimulation were administered.

CASE IV.—W. H. G., age forty-one, male. Admitted to Dr. D. E. Despard's service February 3, 1923, with a crushing laceration of the left forearm when the patient was caught in the gears of machinery in a rope factory. A débridement was performed and the ulnar artery was tied. There was no fracture and there was no tendon involvement. The radial artery showed injury. It was macerated and filled with clot for some distance. February 5, 1923, infective processes were noted in the lower forearm. The culture report of February 6, 1923, showed the presence of gas bacilli. Radical incision and drainage of the left forearm was done February 6, 1923. The Carrel-Dakin treatment was instituted. February 7, 1923, the process was progressive and amputation of the arm was performed three inches above the elbow. Patient became very toxic, pulse very high and temperature progressively higher through February 8, 1923. Death February 9, 1923.

CASE V.—H. B., age thirty-eight, male. Admitted to service of Dr. D. L. Despard, July 6, 1923, with a deep laceration of the left forearm. The radius and ulna were fractured. All arteries except the interossei and all the nerves were severed. Débridement and sterilization of the wound were carried out, radical drainage was instituted while tetanus anti-toxin was given upon admission. July 8, 1923, a peculiar odor was noted about the dressings. Induration and crepitation were present with a parchment-like appearance in the exposed muscle. Gas was found issuing in the wound in the forearm. Amputation was performed in the upper arm. Recovery was uneventful.

CASE VI.—R. L., age fifty-four, male. April 18, 1925, was admitted to the service of Dr. L. J. Hammond with a laceration of the right leg below the knee, in which the skin was so ground with cinders and dirt, that it was hardly recognizable. The gastrocnemius and soleus were partly torn from their origin and severely mutilated. There was a fine gritty material uniformly scattered throughout the tissues. A débridement was done. April 19, 1925, at 2 P.M., while the patient's general condition appeared satisfactory, there was no pulsation felt in the foot. At 6 P.M. this day, crepitation was noted at the right knee. At 10 P.M. crepitation and induration had progressed beyond the inguinal ligament. Radical multiple incisions were made throughout the thigh and abdomen. Gauze strips, soaked in neutral 1 per cent. acriflavine, were laid loosely in the wound; 100 c.c. of gas bacillus serum were given, intravenously. Patient died, April 20, 1925, at 3 A.M.

CONCLUSIONS

Christopher's remarks in 1922 surely have brought considerable increase in the number of cases reported from civil surgery. All authors using anti-toxic sera give urgent advice to use these aids prophylactically and curatively.

BIBLIOGRAPHY

- ¹ Welch and Nuttal: Bull. Johns Hop. Hosp., 1892, vol. i, p. 410.
- ² Greely, W.: Idiopathic Gas Gangrene. Bull. Johns Hop. Hosp., 1916, vol. xxvi, p. 216.
- ³ Simonds, J. S.: Welch Bacillus. Rockefeller Monograph, No. 5, 1915.

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- ⁴Barney and Heller: Detailed Bacteriologic Study of a Case of Gas Gangrene. Arch. Surg., 1922, vol. iv, p. 470.
- ⁵Pilcher, J.: Considerations of Gas Bacillus Infections with Special Reference to Treatment. ANNALS OF SURGERY, 1925, vol. lxxxi, p. 198.
- ⁶Weinberg, M.: Bacteriological and Experimental Researches on Gas Gangrene. Proc. Royal Soc. Med., London, 1916, vol. ix.
- ⁷Wright, A.: Conditions which Govern the Growth of the Bacillus of Gas Gangrene in Artificial Culture Media. Royal Soc. Med., 1916, vol. ix.
- ⁸Bull and Pritchett: Toxin and Antitoxin of and Protective Inoculation Against Bacillus Welchii. Jour. of Exper. Med., July, 1917.
- ⁹Taylor, K.: Gas Gangrene, Its Causes and Treatment. Bull. Johns Hop. Hosp., 1916, vol. xxvii, p. 308.
- ¹⁰McNee and Dunn: The Method of Spread of Gas Gangrene into Living Muscle. Brit. Med. Jour., 1917, vol. ccv, p. 610.
- ¹¹Blake, J.: War Recollections, Military Surgeon, 1926, vol. 1, p. 25.
- ¹²Binnie, J. F.: Keen's Surg., vol. viii.
- ¹³Christopher, F.: Gas Gangrene in Civil Surgery. Int. Clinics, 1922, vol. i, p. 129.
- ¹⁴Jennings, J. E.: Rôle of Welch Bacillus in Gangrenous Appendicitis and Use of Antitoxin of Bull and Pritchett on its Treatment. New York M. J., 1923, p. 682.

OBSERVATIONS ON THE SURGERY OF THE LARGE ARTERIES*

WITH REPORT OF CASE OF LIGATION OF THE INNOMINATE ARTERY
FOR VARICOSE ANEURISM OF THE SUBCLAVIAN VESSELS

BY EMILE HOLMAN, M.D.

OF SAN FRANCISCO, CALIF.

PROFESSOR OF SURGERY IN THE STANFORD UNIVERSITY MEDICAL SCHOOL

AGES ago Celsus, Galen, and Paulus Aeginata began a discussion on the ligation of large arteries which has continued unabated down the many centuries. That the question had not been settled has been demonstrated in recent years by improvements introduced from the proving ground of military surgery,¹ and additional evidence from the experimental laboratory is now available, in support of a new procedure that may be applied in this comparatively simple operation. To illustrate some of the principles underlying the surgery of the large vessels, certain experiences from the operating room and laboratory are presented.

Ligation of the Innominate Artery.—That ligation of the innominate artery is a dangerous surgical procedure is apparent from a mortality of approximately 66 per cent. in the recorded cases. As the circumstances that demand it occur but rarely, the following case report may prove of interest.

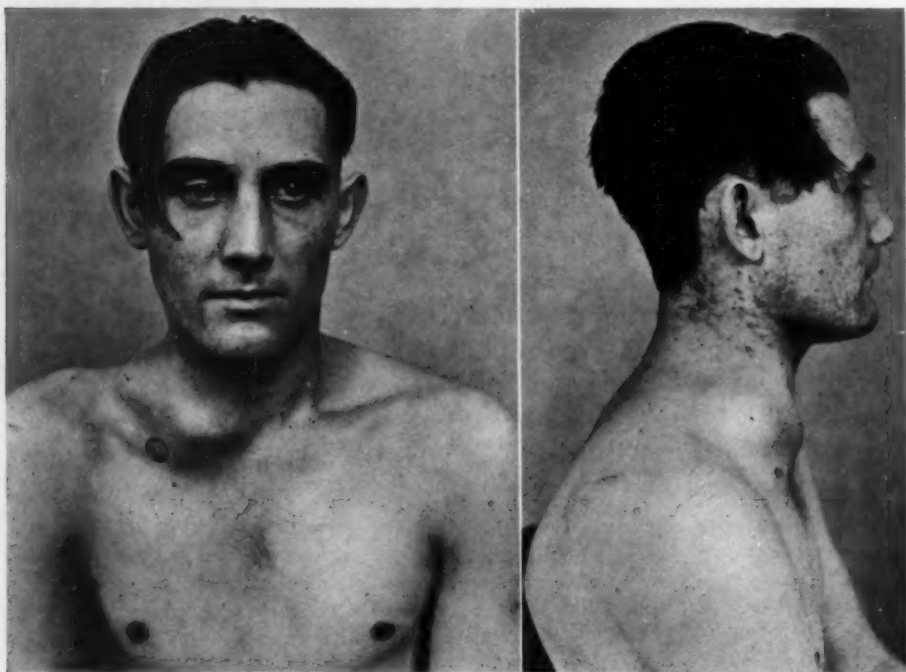
W. M. P., a coal miner, twenty-five years of age, sustained October 22, 1922, a pistol shot wound in the right clavicular region. A profuse hemorrhage occurred but this was easily controlled, after an excessive loss of blood, by slight pressure. Several days after the accident, the patient discovered a filbert-sized tumor presenting just above the middle of the right clavicle, about 2 cm. above the small healing wound of entrance. At the time of discovery, he noticed in it a continuous buzzing, like that of a bee, which seemed to be more pronounced with each beat of the heart. There was a slow but gradual increase in the size of the swelling during his five weeks' stay in bed, and a much more rapid increase in the few days that elapsed following his discharge from the hospital. There was no paralysis at any time. Following the accident the patient noted a vigorous beating of the heart even when lying flat in bed, and a very rapid pulsation with the slightest effort.

Examination.—On his admission to the Johns Hopkins Hospital on November 29, 1922, a large tense pulsating swelling occupied the supraclavicular fossa on the right extending from the midline in front to the anterior border of the trapezius in back (Fig. 1). The point of entrance of the bullet was marked by a small scar located just above the midpoint of the clavicle. There was no wound of exit, and a röntgenogram revealed the bullet in the region of the left apex. A continuous thrill was palpable, more pronounced in systole. On auscultation a loud, continuous "machinery-like" murmur was heard, also more pronounced in systole. Deep pressure applied immediately above the centre of the clavicle caused both the thrill and the bruit to disappear entirely. With their disappearance the patient noticed, subjectively, a temporary slowing of the pulse. Release of the pressure was followed momentarily by a feeling of rapid beating of the heart. Deep pressure sufficient to obliterate the thrill and bruit also caused very definite though transitory alterations in the general blood-pressure. Before compression, the

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pressure in the left arm was 108 systolic and 62 diastolic. On deep compression above the centre of the clavicle the systolic pressure rose momentarily to 112 to 114, dropping immediately to 108. On releasing this compression, the pressure fell to 102, recovering almost immediately to 108. Variations in the diastolic pressure on compression of the artery were not demonstrable, but on releasing the compression, the diastolic pressure fell to 48, recovering within a few seconds to 62. Before operation, the systolic blood pressure in the right arm was consistently 4 to 8 mm. Hg. lower than in the left arm. The superficial veins of the forearm were more prominent on the right than on the left.



FIGS. 1 and 2.—Photographs before operation. The circle indicates point of entrance of bullet. Note the evident enophthalmos.

There were no disturbances of motion or sensation in the right arm. The relative cardiac dullness measured 3 cm. x 8.5 cm. and a teleoröntgenogram showed no cardiac enlargement.

In view of the continuous thrill and bruit, and the definite though slight variations in blood pressure and pulse on compression of the swelling,² a diagnosis of varicose aneurism of the subclavian vessels was made. The communication between the artery and vein was probably a small one,³ but associated with large false aneurismal sacs arising from the wounds in the vessels.

The operation was planned to expose the subclavian artery and vein by resection of the clavicle and, either to close the wounds in the vessels, or to perform a quadruple ligation proximal and distal to the abnormal communication. Having in mind the possible necessity of placing a temporary ligature on the innominate and carotid arteries, the exposure of these vessels was first practiced in the anatomical laboratory.

Operation.—A horizontal incision was made along the line of the clavicle to the sternum, which bisected a median vertical incision at right angles to it. The medial two-thirds of the clavicle was resected subperiosteally. At the junction of its middle and inner thirds, the clavicle showed some erosion, and the periosteum posteriorly was missing over an area about 1.5 cm. in diameter. The black, blood-stained appearance

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of the tissues in this area made us apprehensive lest the clavicle formed a part of the wall of the aneurism. This fear had just been expressed, when the aneurism burst at this point with the escape of a large gush of *arterial* and *venous* blood under great pressure. Fortunately, the tide was effectively and immediately stemmed by the operator's thumb placed in the defect in the periosteum. The force of the pulsation and the size of the stream which had suddenly engulfed the field was sufficient to preclude any possibility of removing the thumb even for an instant without exsanguinating the patient. Dr. William F. Rienhoff, my able assistant, proceeded with the resection of the clavicle and sternum, and Dr. Robert T. Miller, Jr., very kindly stepped in to expose the innominate artery and to place around it a tape ligature for its temporary control. Included in the ligature was a small length of rubber tubing which enabled us to occlude the artery without crushing its walls, and which would permit us to remove the tape without damage to the vessel if so desired. The common carotid was exposed and occluded in similar manner. Following the occlusion of these arteries the pulsation of the swelling ceased, and the diminished pressure in the sac enabled me to release my thumb and to continue the operation from this point. By pressure on the aneurism just above the defect in the periosteum the escape of blood was completely controlled, thus permitting the application of a number of interrupted silk sutures, deeply placed so as to include the periosteum and underlying tissues. A second line of sutures was applied burying the first. These sutures included in all probability the underlying subclavian vein. Following their application, with the temporary ligatures on the innominate and carotid vessels in place, no bleeding from the defect in the sac occurred. The carotid ligature was removed without bleeding from the aneurism. Slight release of the tape encircling the innominate artery permitted pulsation to return in the sac accompanied by some bleeding. Accordingly, a permanent tape ligature, occluding the innominate artery but not crushing it, was applied. The patient's condition, as revealed by a weak and rapid pulse, prevented any further procedures, and the wound was closed in layers *without drainage*.

There was some apprehension lest ligation of the artery alone, proximal to an arteriovenous communication, would result in gangrene of the limb, but as previously noted, it seemed highly probable that the subclavian vein was included in our deeply placed sutures. This would account for the complete and permanent cessation of the thrill and bruit which followed the operation.

An interesting observation immediately after the completion of the operation was the very marked pallor and complete absence of perspiration on the right side of the face ending abruptly in the midline of the forehead, nose, and chin. The left side of the face was flushed and perspiring profusely. This difference had completely disappeared by eight o'clock in the evening, six hours after the operation. Immediately after the operation, the right radial artery was collapsed and pulseless. Within eight hours, the radial vessel, though filled with blood, showed no pulsation. Twenty hours later, a feeble pulsation had returned in the right wrist. There were no paralyses or objective sensory variations, but there was a subjective numbness of the entire right arm and hand which disappeared within forty-eight hours. Two days after the operation the blood-pressure in the left arm was recorded as 132 systolic and 76 diastolic. Four days after operation, the large pulsatile swelling had subsided almost completely and the neck had again assumed a normal contour. There was no pulsation, bruit, or thrill. On two occasions,

thirteen and twenty days after operation, a small opening along the line of incision was made to evacuate old fluid blood. On the day of discharge from the hospital, a good pulse could be felt at the wrist, and the right carotid and temporal vessels felt full and firm. There was no difference in the appearance of the veins of the two arms but venous pressure on the right was slightly increased. The veins of the left arm were completely collapsed when the arm was elevated four degrees above the horizontal, whereas the veins on the right did not collapse until the arm was 20 degrees above the horizontal. This was interpreted as indicating that the subclavian vein had been occluded at the operation. Subjectively the patient felt that his heart was beating less forcibly and less rapidly than before operation. The blood-pressure in the right arm was 76 systolic and 74 diastolic, and in the left arm 120 systolic and 76 diastolic, the general blood-pressure being definitely increased since operation.

One year after operation the patient again appeared for examination. His right arm still seemed weaker than the left, but gradual improvement was taking place. Some interesting observations had been made by the patient: He perspired only on the left side of his face; the right face and right arm felt colder in cold weather than did the left; when hot or excited he felt a throbbing on the left side of his head and not on the right. On examination, a slight enophthalmos was still present, but the pupils were equal (Fig. 2). The neck showed no swelling or abnormal masses. The pulsation in the right carotid and right radial arteries was weak, and followed the pulsation in the left carotid and radial vessels by a definite interval. There was no atrophy nor objective weakness of the arm muscles. The heart was normal. The blood-pressure in the left arm was 118 systolic and 92 diastolic, and in the right arm 90 systolic and 70 diastolic. It seemed probable that a permanent cure of the aneurism had been effected.

In spite of the failure at operation to demonstrate a definite communication between the artery and vein, all the clinical evidence, together with the escape at the operation of both venous and arterial blood from the defect in the aneurismal wall, justified the diagnosis of varicose aneurism of the subclavian vessels. If this diagnosis be accepted, it is difficult to explain the success of this operation on the simple ligation of the innominate artery, and it seems highly probable that the occlusion of the subclavian vein contributed to the effectual elimination of the aneurism. This inference is made because of experimental observations that complete cessation of the thrill and bruit of a fistula follows the ligation of the vein proximal to the abnormal communication.²

Simultaneous Ligation of Artery and Vein.—A better understanding of the treatment of this type of abnormal communication between the vessels may be credited to the extensive experience of the eminent English surgeon, Sir George H. Makins.¹ In the South African War, proximal ligation of the artery for arteriovenous communications was followed in over 50 per cent. of the cases by gangrene of the limb. This observation, together with similar

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experiences in the early part of the recent war, prompted the recommendation at the Interallied Conference of Surgeons held in Paris in May, 1917, that the ligation of a large artery for injury should be accompanied also by the occlusion of the satellite vein, even though the latter be uninjured. It may be recalled that the writings of eminent surgeons of the past have always stressed the need of preserving carefully the accompanying vein. Aneurism needles were applied so as to avoid injury to the vein. Operations were devised with the primary intent of preserving the vein. It is evident,

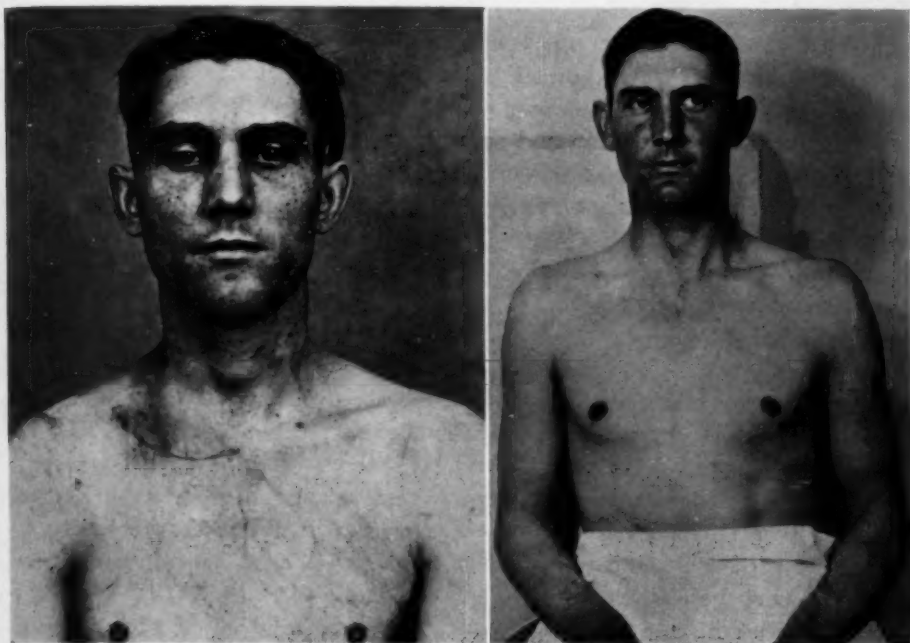


FIG. 3.—Patient four weeks after ligation of the innominate artery. Note persistence of enophthalmos and subsidence of large swelling.

FIG. 4.—One year after operation. Slight enophthalmos still present. The swelling has completely disappeared.

however, that the experiences of Makins were entirely against such a practice, and a number of experiments have been performed to substantiate the claim that it is better to occlude also the satellite vein when any of the large arterial trunks require ligation. Van Kend⁴ reported animal experiments in which plethysmographic tracings demonstrated clearly that, after a previous fall in pressure due to ligation of the artery, a slight rise in the blood-pressure of the limb followed the application of a ligature to the main vein.

Drummond,⁵ likewise, made some interesting observations on animals in which segments of small bowel had been treated by two different methods: One segment was deprived of its blood supply by ligating the artery alone. A second segment in the same animal was treated by ligating both the artery and the vein. In three instances a definite ring of gangrene appeared, limited to the segment in which only the artery was ligated, whereas no change

occurred in the segment of bowel in which both artery and vein were occluded. Additional corroborative evidence to support Makins' point of view is furnished by Brooks and Martin⁶ who performed ligation of the common iliac artery in the rabbit with and without ligation of the satellite vein. They found in a series of thirty-nine experiments that in those animals in which the artery alone was occluded, 71.5 per cent. developed gangrene of some degree, whereas in those animals in which the accompanying common iliac vein was also ligated, only 33.3 per cent. developed any manifestation of gangrene.

There is evidence also that the function of the limb is less likely to be impaired following simultaneous ligation of artery and vein. Doctor Halsted⁷ records two instructive observations: the excision of a large ilio-femoral aneurism including the deep and superficial veins, was followed by perfect function in the limb of a stevedore accustomed to the hardest kind of labor. In striking contrast to this was the result obtained in another patient whose common iliac artery he had ligated, but not the corresponding vein. In this instance, the patient was prevented by claudication from ever walking more than one or two hundred yards.

In a clinical study by Sehrt,⁸ it was found with reference to the lower extremity, that ligation of the artery alone was followed in 20 per cent. of his cases by gangrene, whereas ligation of both the artery and vein was followed in only 9 per cent. by gangrene. With reference to the upper extremity he found that ligation of the artery alone resulted in gangrene in 7.8 per cent. of the cases and ligation of both artery and vein resulted in no gangrene. He attributes the larger percentage of gangrene in the lower extremity to the absence of large muscle masses bridging the knee as compared with those bridging the elbow.

In a statistical summary by Heidrich⁹ we find that among 995 ligations of the large arteries alone, gangrene occurred 154 times, a percentage of 15.4, and among 198 ligations of both artery and vein, gangrene occurred 17 times, or a percentage of only 8.5.

With these facts before us, there would seem to be no doubt as to the proper procedure which should be followed whenever one of the large arterial trunks requires ligation. One should invariably ligate also the accompanying vein.

A consideration of the hydraulic principles governing blood flow under such conditions leads to the assumption that the site of this ligation should be proximal to the site of the arterial ligation. If, for example, the superficial femoral artery were ligated in Hunter's canal, the collateral circulation would be provided mainly through the deep femoral artery. Normally, the blood flowing through this artery passes through a given set of capillaries in the thigh and leaves the limb by its accompanying vessel, the deep femoral vein. If this vein remains unobstructed, the pressure in the capillary bed of the thigh would be low, and the small volume of collateral blood from the deep femoral artery might readily flow through the accustomed route, with

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its area of low resistance, back to the heart, avoiding entirely the more distal peripheral bed. If, however, in the presence of a ligation of the superficial femoral artery, the common femoral vein be ligated, the resulting increased resistance in the capillary bed of the thigh, together with the lessened resistance in the artery below the ligature, would direct the blood from the deep femoral artery into the small arterial communicating channels of the perforating arteries, thence into the anastomotic vessels about the knee-joint and into the main femoral or popliteal artery leading to the more distal capillary bed. *It seemed from this point of view that ligation of the popliteal artery, or of the superficial femoral artery just proximal to the popliteal space, should under certain circumstances be accompanied not by ligation of the popliteal vein or of the superficial femoral vein, but by ligation of the common femoral vein above the entrance of the deep femoral branch or even above the entrance of the greater saphenous vein.* This procedure would increase the capillary resistance in the thigh and by directing the full force of the collateral circulation into the anastomotic channels about the knee-joint, should lessen the probability of gangrene.

In support of this view convincing experimental evidence may be presented: As previously noted, Brooks and Martin encountered gangrene in 71.5 per cent. of their experimental rabbits in which the common iliac artery alone was ligated. When both common iliac artery and vein were ligated, 33.3 per cent. of the animals developed gangrene with a high mortality. Holman and Edwards,¹⁰ with the above theoretical considerations as the basis for their work, ligated the common iliac artery simultaneously with ligation of the inferior vena cava three centimetres above the confluence of the common iliac veins. Twenty-eight rabbits were so treated followed in only two instances by a limited gangrene of the right extremity, and in each of these instances the operation was complicated by hemorrhage which proved difficult to control. As compared with the results obtained by Brooks and Martin there is no question of a lessened gangrene in this series, a percentage of 7.1 instead of 33.3.

The circumstances demanding the ligation of the vein proximal to arterial ligation would presumably be dependent upon the extent to which collateral circulation had already developed as the result of the lesion which necessitated the ligation. Proximal ligation of the vein would be applicable in all cases which entailed an acute shutting off of the arterial supply, as in traumatic injury to vessels. If for any reason a collateral circulation had already developed, its application would probably be less imperative and perhaps accompanied by a certain degree of danger of swelling of the limb. In the experimental animal there was no swelling of the left limb following the ligation of the vena cava although the arterial supply of the limb remained intact.

This principle is subject to further application: If the artery and vein are ligated simultaneously at the same level, and gangrene later impends—as occurs in 8 to 10 per cent. of the clinical cases—it would be in order to

ligate the vein immediately at a point considerably nearer the heart—a procedure to be carried out promptly before true gangrene had supervened.

Ligation of Artery Proximal to Arteriovenous Fistula.—A further clinically known objection to the ligation of the artery alone proximal to an arteriovenous aneurism was corroborated recently by experimental observations. Arteriovenous fistulæ were produced between the common femoral vessels of the dog. Two weeks later the femoral artery was ligated just proximal to the fistula, resulting in a temporary obliteration of the characteristic thrill and bruit of the fistula. No gangrene supervened, but within a week the thrill and bruit had returned with unabated intensity, due to the very evident development of an extensive collateral circulation. The blood-pressure below the fistula could not be measured immediately after ligation of the artery, but within two weeks it had risen to 110 systolic and 90 diastolic, as recorded by a Pachon sphygmomanometer. Three similar experiments demonstrated the futility of curing such fistulæ in dogs by ligation of the proximal artery alone. It may be inferred, therefore that even if ligation of the proximal artery should not produce gangrene, it would not be effectual in eliminating the fistula.

A more radical procedure is required for the cure of a varicose aneurism, and the most effective methods at our disposal are:

(1) Reestablishment of the artery and vein by separation and suture of the two openings. This procedure is applicable in cases of short duration, but it is not always practicable in those of long duration due to extensive calcium deposits in the wall of the artery.

(2) Quadruple ligation of the main vessels proximal and distal to the fistula with excision of the communication. This procedure Makins found effective whenever used and it is, above all others, the operation of choice, a view recently sustained also by Reid.¹¹

(3) The method of Matas,¹² which sutures the opening in the artery by approaching it through the dilated vein. Although applicable in certain instances this method, too, may be found unsafe and impracticable because of the altered and weakened state of the arterial wall at the site of the fistula.

Division of Large Arteries Between Ligatures Preferable to Ligation in Continuity.—A further point to be considered in the surgery of the large arteries pertains to the question of ligation in continuity, which remains still a matter of dispute. Thus wrote Ballance and Edmunds¹³ in 1886:

"The earlier surgical writers, Galen, Paulus Aeginata and others recommend the application of two ligatures and the division of the artery between them, an operation which now bears the name of Abernethy (1827), but many others have practiced it. This way of tying an artery probably originated in the observation that arteries in amputation stumps are less prone to secondary hemorrhage than those tied in continuity; a fact which explains the favour with which the operation has lately been received, and gives the reason for its attempted revival. The validity of this analogy was questioned by Sir Charles Bell sixty years ago, and the procedure appears unnecessarily severe."

However, it has been observed occasionally that ligation in continuity is followed by a reestablishment of the arterial lumen with subsequent recur-

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rence of the lesion which prompted the ligation. To prevent this, Horsley¹⁴ has recently advocated again the double ligation of the artery with division of the vessel between the ligatures.

The danger of this reestablishment of the lumen is of less importance than the probability of secondary hemorrhage through erosion of the vessel wall. The development of infection would lead almost inevitably to such a result, but *even in the absence of infection* many of the fatalities following ligation in continuity may be attributed to an erosion of the wall. There is evidence that this erosion is less likely to occur if the vessel is ligated at two points and divided between ligatures. Such division permits a marked retraction of the vessel due to its elastic elements, with an actual thickening of its walls. The resulting increased elasticity of this blind arterial end absorbs the force of each pulsation, and effectively dissipates the pulsatile pressure which in ligation in continuity spends itself against the ligature itself, with frequently disastrous results. Recent experiments have shown that the abdominal aorta when ligated will retract $2\frac{1}{2}$ or 3 cm. with an actual perceptible thickening of its walls. Reichert's¹⁵ experiences confirm this observation.

Partial Ligation of Large Arteries to be Avoided.—The *partial* ligation of large arteries is a dangerous procedure. This was brought home to us recently in a number of experiments¹⁶ in which the pulmonary artery and aorta were partially ligated just beyond the pulmonic and aortic valves in an effort to simulate stenosis of these vessels. Out of five partial ligations of the aorta only one experiment went to full completion because of rupture of the vessel wall with fatal hemorrhage.

Simultaneous Ligation of Carotid Artery and Jugular Vein.—Our discussion so far has been directed mainly to a consideration of the effect of ligating the large vessels leading to the extremities. There remains also the question of ligation of the common carotid artery. This procedure is frequently followed by a hemiparesis of the opposite side due to nutritional disturbances in the cerebrum. Additional clinical phenomena that have been observed following ligation of the common carotid are convulsions, drowsiness, coma, cardiac and respiratory irregularities, fall in temperature, blindness, diplopia, and motor and sensory losses on the opposite side.

A full discussion of the cerebral changes that follow the ligation of the common carotid artery is presented by Zimmermann.¹⁷ He quotes Pilz¹⁸ who gathered together 600 cases of ligation of the common carotid artery, 32 per cent. of whom presented cerebral symptoms. Zimmermann records seventy ligations of the carotid performed since the introduction of asepsis, of which 26 per cent. were followed by cerebral symptoms. One may well speculate what results could now be achieved with a simultaneous ligation of both the common carotid artery and internal jugular vein. Indeed, arguing by analogy from the better results obtained by ligation of both vessels in the extremities, Makins very emphatically advises occlusion of the jugular vein whenever ligation of the common carotid artery is considered. Proping,¹⁹ in discussing the causes of gangrene following ligation of the great

arterial trunks, reports two instances in which simultaneous ligation of the jugular and carotid vessels was unattended by cerebral disturbances. Halsted held that ligation of the common carotid artery could be performed with impunity in the young, and that the incidence of cerebral disturbances following ligation of the common carotid increased with age.

Simultaneous Ligation of Innominate and Carotid Arteries for Subclavian Aneurism.—It is important to note also that Thompson²⁰ presents evidence indicating that when circumstances demand ligation of the innominate artery, it is well to ligate also the common carotid artery. He found that only 41 per cent. of seventeen cases recovered following ligation of the innominate alone, whereas 66 per cent. of twelve cases recovered following ligation of both the innominate and carotid arteries. He contends that ligation of the carotid artery is indicated because "it diminishes still further the flow of blood through the aneurism and thereby promotes consolidation and it prevents an excessive drain of blood from the circle of Willis, thus avoiding cerebral anæmia." The ligation of both carotid and innominate arteries would probably increase the percentage of subsequent gangrene in the limb unless the innominate vein were also ligated.

Importance of Avoiding Sepsis. Drainage Contra-indicated.—The success of operations upon the large vessels depends in great measure upon the avoidance of sepsis. The strictest precautions against infection must be followed throughout, particular attention being paid during a prolonged operation to exclude the skin from the operative field. Drainage in vascular surgery must be scrupulously avoided. Through the insistence and example of the late Professor Halsted, the drainage of clean wounds of whatever nature is becoming less and less a necessary part of modern surgical technic. Many surgeons are still loath to discard such drainage, but the disciples of Halsted no longer hesitate to close completely all clean wounds, including those following thyroidectomy, herniotomy, amputations, or the excision of large tumors. The better healing and lessened incidence of infection that follows such a procedure is easily demonstrable. For identical reasons it cannot be too emphatically stated that in the surgery of the large vessels the packing and drainage of wounds is inviting almost certain disaster. Should the wound at any time following operation fill up with fluid, it is a simple matter to evacuate it under strictly sterile precautions. Only in the presence of obvious infection should a drain or irrigating tube be introduced following such an evacuation of a wound.

SUMMARY

Recapitulating the points which seem to require special emphasis in the surgery of the large vessels, the following considerations are presented:

Ligation of one of the large arterial trunks should be accompanied also by occlusion of the accompanying vein. From experimental evidence, a new principle in the simultaneous ligation of artery and vein seems admissible:

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Under certain circumstances it is preferable to ligate the vein *proximal* to the site of the arterial ligation, *e.g.*, ligation of the popliteal artery should be accompanied by ligation of the common femoral vein above the entrance of the deep femoral and saphenous branches. In the experimental animal, the incidence of gangrene was greatly decreased by the application of this principle.

A coarse ligature such as a broad tape should be applied to the large arterial trunk rather than fine ligatures, since the latter cut through the arterial wall with distressing rapidity.

If feasible, division of an artery between ligatures should supersede ligation in continuity, even of the abdominal aorta, primarily because of the lessened possibility of fatal erosion of the arterial wall.

Partially occluding ligatures and crushing ligatures applied to large vessels are both equally and highly dangerous because of fatal rupture of the wall of the vessel. The ligature should be tied so as to occlude the artery, but not to crush it. Likewise it would seem better not to use a partially constricting ligature central to a totally occluding one.

Proximal ligation of the artery for an arteriovenous fistula is contraindicated not only because of the imminent danger of distant gangrene, but also because it is entirely futile in eliminating the fistula, should gangrene be averted.

Following operations upon the large vessels, the wound should be completely closed without drainage.

BIBLIOGRAPHY

- ¹Makins, G. H.: Gunshot Injuries to the Blood-vessels. 1909, John Wright & Sons, Bristol, England.
- ²Holman, E.: Experimental Studies in Arteriovenous Fistulas, I. Blood Volume Variations. Arch. Surg., Nov., 1924, vol. ix, p. 822.
- ³Holman, E.: Arteriovenous Aneurism, Clinical Evidence Correlating Size of Fistula with Changes in the Heart and Proximal Vessels. ANNALS OF SURGERY, Dec., 1924, vol. lxxx, p. 801.
- ⁴Van Kend: Quoted by Makins.
- ⁵Drummond: Quoted by Makins.
- ⁶Brooks, B., and Martin, K.: Simultaneous Ligation of Vein and Artery: An Experimental Study. Journal A. M. A., June 9, 1923, vol. lxxx, p. 1678.
- ⁷Halsted, W. S.: Ligations of the Left Subclavian Artery in its First Portion. Johns Hopkins Hospital Reports, vol. xxi, p. 1921.
- ⁸Sehrt, E.: Ueber die künstliche Blutlehre von Gliedmassen und unterer Körperhälfte sowie ueber die Ursache der Gangrän des Gliedes nach Unterbindung der Arterie allein. Med. Klin., Berlin, 1916, vol. xii, p. 1338.
- ⁹Heidrich, L.: Ueber Ursache und Häufigkeit der Nekrose bei Ligaturen grosser Gefässstämme. Beit. zur klin. Chir., vol. cxxiv, 1921, pp. 607-638.
- ¹⁰Holman, E., and Edwards, M.: A New Principle in the Surgery of the Large Vessels: Ligation of the Vein Proximal to the Site of Ligation of the Artery. An Experimental Study. (In Press.)
- ¹¹Reid, M. R.: The Treatment of Arteriovenous Communications. Arch. Surg., Aug., 1925, vol. xi, p. 237.

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- ¹² Matas, R.: Some Experiences and Observations in the Treatment of Arteriovenous Aneurisms. *ANNALS OF SURGERY*, April, 1920, vol. lxxi, p. 403.
- ¹³ Ballance, C. A., and Edmunds, W.: The Ligation of the Larger Arteries in Their Continuity. *Med. Chir. Trans.*, London, 1885-1886, vol. lxix, p. 443.
- ¹⁴ Horsley, J. S., Jr.: Healing of Arteries After Different Methods of Ligation. *Journal A. M. A.*, Oct. 17, 1925, vol. lxxxv, p. 1208.
- ¹⁵ Reichert, F. L.: An Experimental Study of the Anastomotic Circulation in the Dog. *Johns Hopkins Hospital Bulletin*, Dec., 1924, vol. xxxv, p. 385.
- ¹⁶ Holman, E., and Beck, C. S.: The Physiological Response of the Circulatory System to Experimental Alterations. III. The Effect of Aortic and Pulmonic Stenosis. *Jour. Clin. Invest.* (In Press.)
- ¹⁷ Zimmermann, W.: Ueber die Gehirnweichung nach Unterbindung der Carotis communis. *Beitr. Z. Klin. Chir.*, 1891-1892, vol. viii, p. 364.
- ¹⁸ Pilz: Zur Ligatur der Carotis communis. *Archiv. für klin. Chirurgie*, 1868, Band ix, p. 257.
- ¹⁹ Propping, K.: Ueber die Ursache der Gangrän nach Unterbindung grosser Arterien. *Münchener Medizinische Wochenschrift*, 1917, vol. lxiv, p. 598.
- ²⁰ Thompson, J. E.: Ligature of the Innominate Artery for Cure of Subclavian Aneurisms. *ANNALS OF SURGERY*, June, 1915, vol. lxi, p. 641.

CONTRIBUTION TO PLASTIC SURGERY *

REMOVAL OF SCARS BY STAGES; AN OPEN OPERATION FOR EXTENSIVE LACERATION OF THE ANAL SPHINCTER; THE KONDOLEON OPERATION FOR ELEPHANTIASIS

By WALTER E. SISTRUNK, M.D.

OF ROCHESTER, MINN.

FROM THE DIVISION OF SURGERY OF THE MAYO CLINIC

SIMPLE surgical procedures are often used and forgotten, and for this reason I wish to report in this symposium on plastic surgery two simple but useful surgical measures which, no doubt, have been used before but to which I am unable to find references. I also wish to discuss certain modifications of the Kondoleon operation which have proved valuable in improving the end-results in the treatment of elephantiasis.

REMOVAL OF SCARS BY STAGES

The skin, probably on account of its elastic fibres, easily stretches when put under tension. We see examples of this in large tumors, goitres, and in cases of elephantiasis after the oedema has been reduced by bandages and rest in bed. It is possible to take advantage of this characteristic of the skin and to remove scars situated in certain regions, where it would be inadvisable to use grafts in stages, allowing the skin after each operation to stretch and again become loose and movable. From the appearance of scars following skin grafts, from the color of the skin in these areas, or from the border of the graft when thick grafts have been applied, one can usually tell that grafts have been used. The appearance of the scar for which the original operation was performed may have been greatly improved, but the result is not always that desired by the operator.

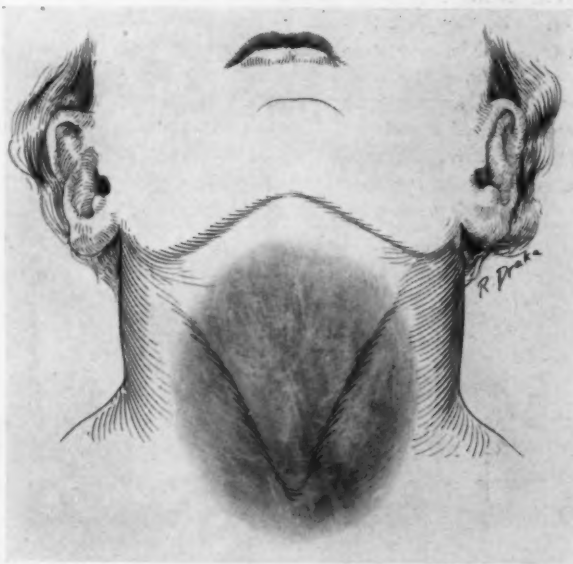


FIG. 1.—Appearance of Röntgen-ray burn before operation.

CASE I.—The patient was a woman, aged thirty, who had been affected with goitre since the age of sixteen. From many exposures to the Röntgen-ray in the treatment

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WALTER E. SISTRUNK

of this goitre, a superficial burn resulted and the scar which followed involved almost the entire anterior surface of the neck from the hyoid bone nearly to the clavicle. Its appearance was so unsightly that the young woman was quite sensitive about it and to hide it wore, at all times, a scarf or a high collar. She had repeatedly consulted sur-

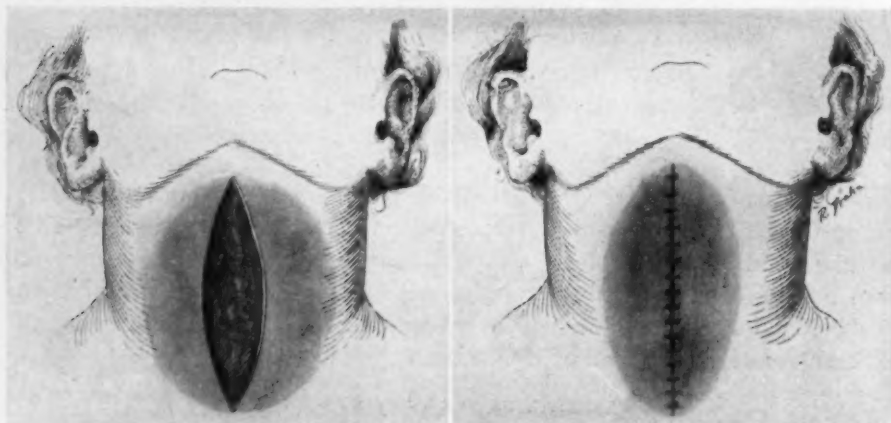


FIG. 2.—First stage of the operation. A small portion of the burned area excised and the wound closed.

geons in the hope that it could be removed, but had always been advised against operation since they felt that the skin graft which would be necessary after removal of the scar would be almost as unsightly as the burn.

Examination showed the scar of a superficial burn with movable skin which was unattached to the deeper tissues. It was quite red in appearance and showed many large, dilated capillaries. Apparently nothing short of complete excision of the burn would improve the appearance of the neck. It was accordingly suggested that the burn be removed by stages, to which method of treatment the patient gladly consented.

As much of the skin as could be removed and still allow closure of the edges of

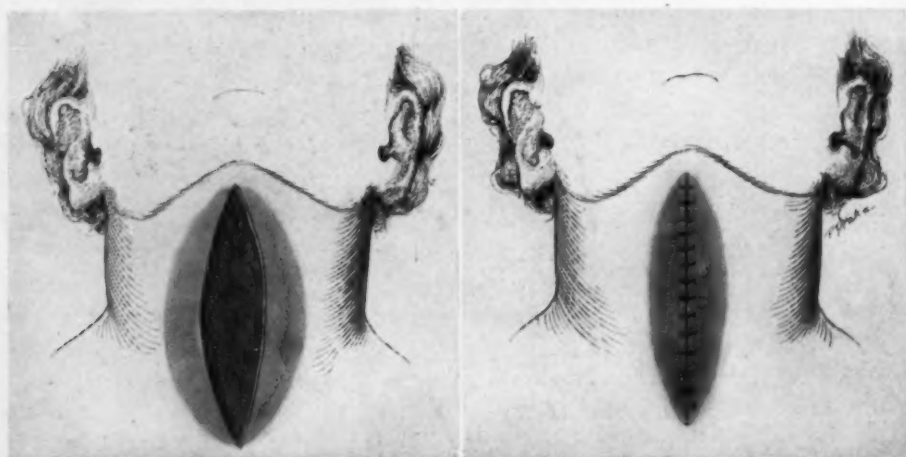


FIG. 3.—Second stage of operation (repetition of first stage).

the wound without tension was removed. The skin and superficial fat only were removed and special effort was made to avoid undermining the skin in order to prevent adhesions between it and the deeper structures which would later prevent the skin being stretched by massage, and so forth. It was possible in this way to remove about one-

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third of the scar. Following the operation, the patient stretched the skin by movements of the neck and by massage. On her return six months later, the skin was as loose and pliable as it was at the first operation and the scar was only two-thirds as large. A similar operation was then performed, to remove about one-half of the remainder of the scar. The patient returned again after six months and, at a third operation, the remaining portion of the scar was removed. Now only a single line may be seen. In this way the skin was removed from almost the entire anterior surface of the neck without a graft (Figs. 1, 2, 3, and 4).

I have since employed the same method in removing an ugly scar from the anterolateral surface of the neck. The patient, a young woman, had

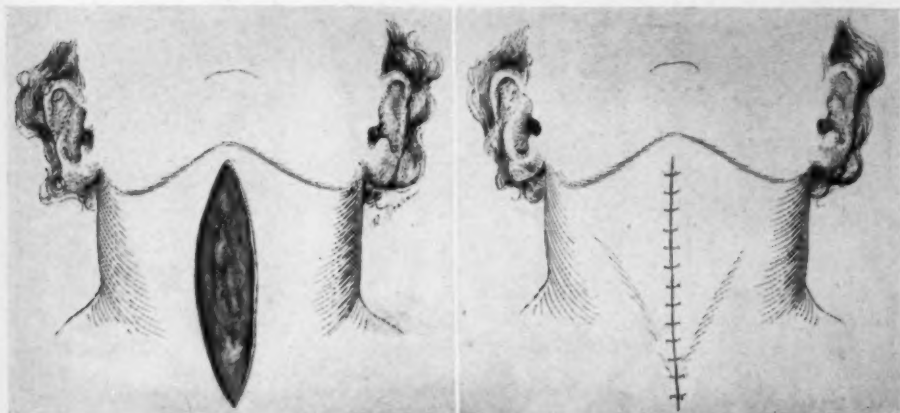


FIG. 4.—Third stage of operation. Remainder of burned area excised and wound closed.

suffered a severe superficial burn following the application of a strong solution of iodine. The results of the operation were excellent.

AN OPEN OPERATION FOR EXTENSIVE LACERATION OF THE ANAL SPHINCTER

In the ordinary case in which a primary operation is performed for a tear of the external sphincter ani, the operation almost universally described in text-books is quite satisfactory and is usually followed by good results. However, an occasional case is seen in which practically the entire external sphincter has been destroyed, usually either by an infection, as is seen in perirectal abscesses, or as a result of an operation for rectal fistula.

In the type of case which I am attempting to describe, the sphincter has often been largely destroyed and the nerves supplying it usually impaired or destroyed. In many such cases it is almost impossible to draw the ends of the sphincter together without such tension as to prevent satisfactory healing. The anus, too, in such cases, is necessarily so tightly closed in bringing the ends of the sphincter muscle together that too small an opening is left and the muscle ends usually separate during the first act of defecation. Should satisfactory healing occur, the normal control of the muscle is not regained, and the anus cannot be closed even by voluntary efforts.

For some years I have, in treating anal fistula, divided the tissues anterior to the fistulous tract and severed the external sphincter over a probe. In

order to prevent wide separation of the sphincter ends and still be able to pack the fistulous tract with gauze so as to allow the wound to heal from the bottom by granulation, I have sutured the cut ends of the external sphincter muscle to the internal sphincter (levator ani muscle). An operation of this sort has usually cured the fistula and at the same time has established excellent control. The effect on control of bowel movements has been so satisfactory that I have extended the use of the operation and now follow practically the same method in operating for complete lacerations of the

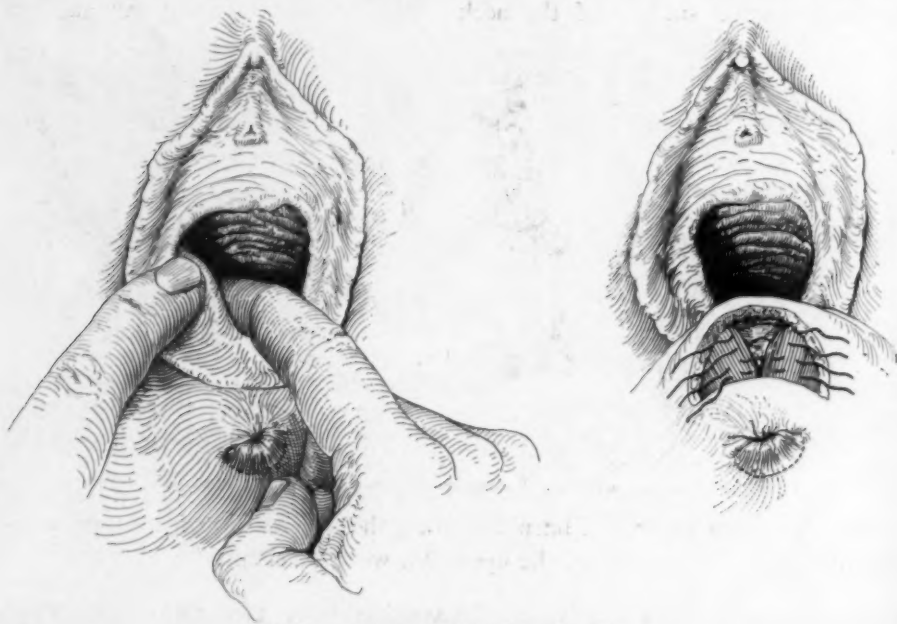


FIG. 5.—Exposure of levator ani muscle.

perineum and in repairing the anal sphincter when it has become incompetent from any cause.

Technic.—A curved transverse incision is made just above the anus or along the vaginocutaneous margin, and the levator ani muscle isolated. This muscle is sutured over the anterior rectal wall, as in an ordinary perineorrhaphy. The ends of the external sphincter which are often widely separated are isolated and sutured to the levator ani, the ends being brought as closely together as possible without too much tension. If sutured under too much tension, satisfactory healing will not occur, as the tissues will slough and the sutures fail to hold. The ends of the muscle are usually brought close enough together to close the anus so that it fits snugly around an index finger introduced into the rectum. The wound is left open and packed with iodoform gauze, as is done in operations for rectal fistula. The gauze is usually held in position by a suture placed through the edges of the skin and loosely tied in such a way that the edges of the skin are left wide open. After seven or eight days it may be removed and a healthy granulating surface usually

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results which slowly heals. The scar tissue which forms in the healing process unites fairly satisfactorily the edges of the external sphincter. If the nerve supply to this muscle is uninjured, the patient usually develops normal control; if it has been injured, normal control will not be regained but the patient will usually be able to close the external sphincter voluntarily by elevating the levator ani through efforts to close the vagina or to lift the rectum upwards. Through this voluntary effort, patients are usually able to close the anus fairly tight upon a finger introduced into the rectum and can

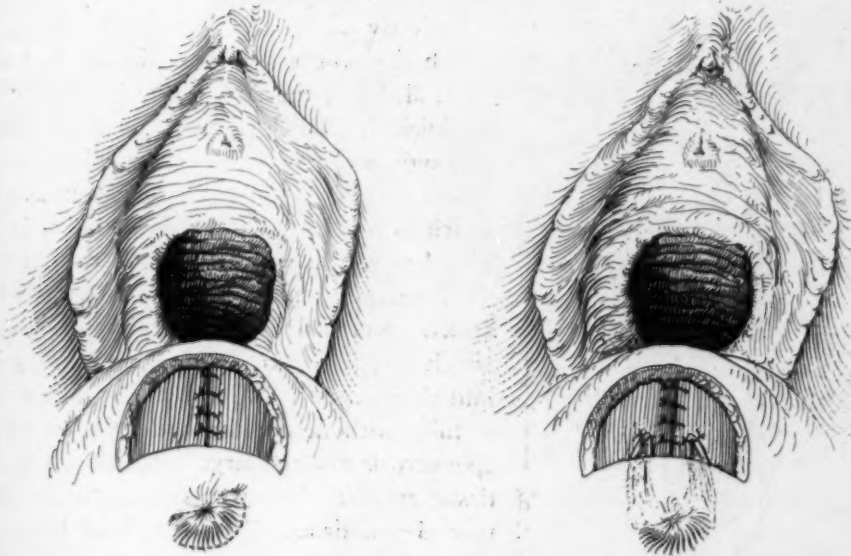


FIG. 6.—Levator ani muscles sutured together and remaining portion of anal sphincter sutured to them.

usually keep the anus closed sufficiently long to control gases and fæces until the toilet can be reached. The ability to close the anus by voluntary effort gives the patient great mental relief. The operation differs from that ordinarily performed for complete lacerations, as I have seen it described and carried out. In the common operation, the ends of the sphincter are merely sutured together, often under great tension, without any attempt to suture them to the levator ani. The method I have described tends to give much better voluntary control, the only control that can be expected in certain cases in which the sphincter has largely disappeared and its nerve supply been injured (Figs. 5 and 6).

More satisfactory results are obtained when patients are given castor oil forty-eight hours previous to the operation and allowed only water, fruit juices and sugars after the oil has acted. I usually induce constipation by administering paregoric before the operation. This medication is also continued for about ten days after the operation, during which time patients are given only water, fruit juices and broth. After ten days, oil enemas, consisting of 180 c.c. of olive oil, are given by rectum morning and night, and a

mild laxative, such as milk of magnesia, is administered several times a day until satisfactory bowel movements have occurred.

CERTAIN MODIFICATIONS OF THE KONDOLEON OPERATION FOR ELEPHANTIASIS

These changes in the Kondoleon operation have been made after nearly ten years' experience with the operation and contribute to the success of the end-results. At the present time I feel that this operation is of much value

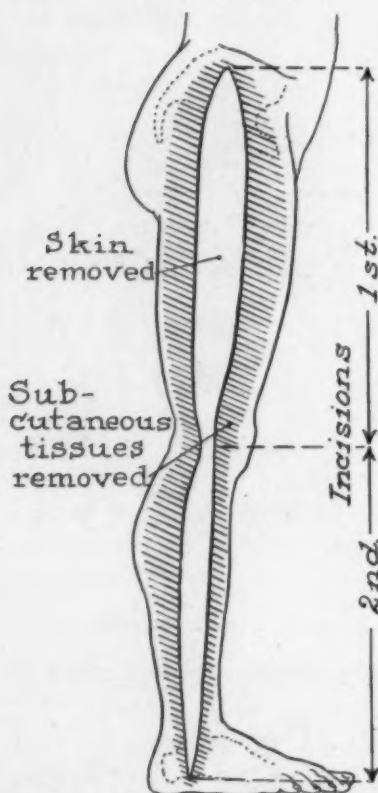


FIG. 7.—Strip outlined and undermined areas shaded.

in dealing with this disease. The operation cannot be considered one which will restore a perfectly normal limb, but as one through which the progress of this disease may be controlled and the size of the limb greatly diminished. Briefly, it may be stated that, although we see congenital elephantiasis, the so-called "idiopathic elephantiasis," which is usually seen in this country, is a sequel to partial or complete obstruction of the inguinal lymph-nodes. Elephantiasis is always preceded by simple lymphcedema which progresses until it gradually merges into elephantiasis. In lymphcedema the skin is thin, without the thickened dermis and aponeurosis and the large quantities of scar tissue seen in the subcutaneous tissues in true elephantiasis. The superficial lymphatic system alone is involved even in advanced cases of elephantiasis and this system is definitely separated from the deep lymphatic system by the aponeurosis covering the muscles. The Kondoleon operation is performed with an idea of connecting these two systems by removing a large amount of this aponeurosis. At the same

time, a large amount of the skin and subcutaneous fat is removed and the skin, with a small amount of the subcutaneous fat, is allowed to become attached to the muscles. When these raw surfaces are apposed, new blood-vessels, new nerves and new lymphatics form, and the superficial lymphatic system is thus connected with the deep system.

I believe that the removal of large amounts of diseased tissue with its blocked lymphatics is one of the very important steps of the operation. Kanaval has called attention to the fact that this was suggested many years ago by Rogers of Milwaukee. Better results are obtained if much larger amounts of the aponeurosis are removed than first suggested by Kondoleon, and I feel that the more tissue removed the better the result. In order that

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large amounts of diseased tissue may be removed and the edges of the skin still be closed, patients should be carefully prepared for the operation by rest in bed for periods of from ten days to several weeks. During this time, the limb to be operated on is kept elevated and firmly bandaged so that the fluids may

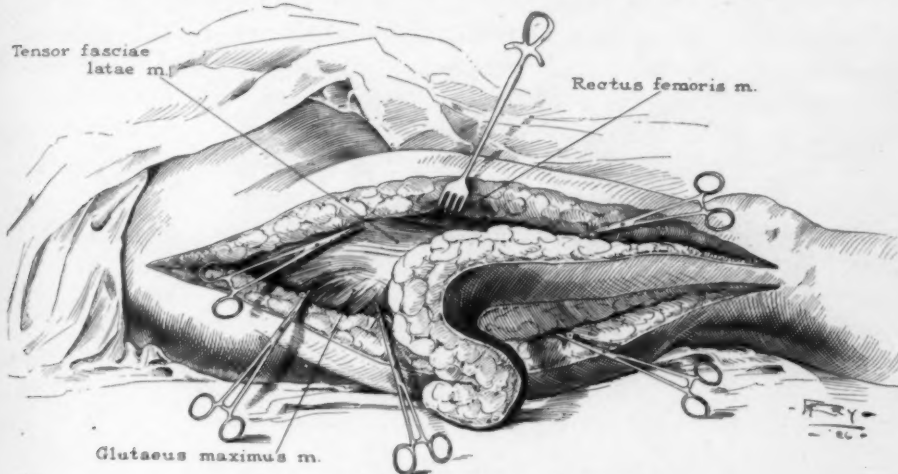


FIG. 8.—Strip nearly excised, vessels clamped.

be pressed out and the œdema diminished. The bandages are changed as often as they become loose and the patients are made to get up and walk rapidly down the hospital halls for a few minutes several times each day, so that the blood-pressure may be kept as near normal as possible. At the

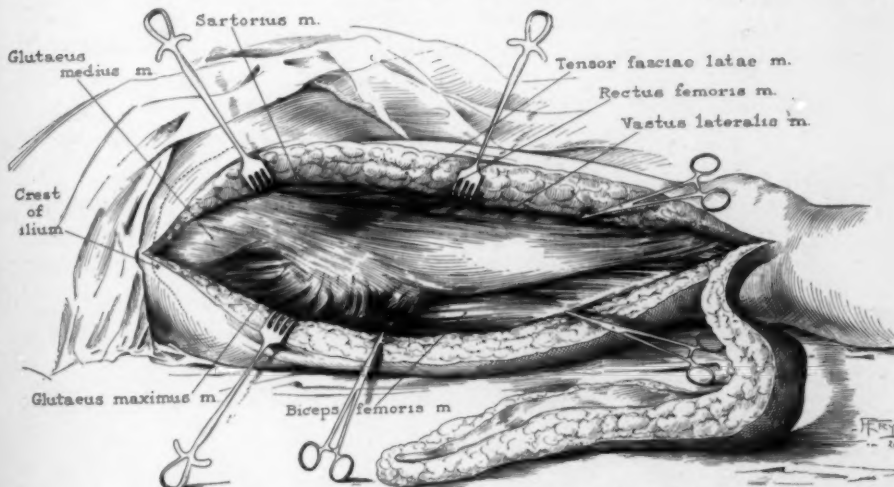


FIG. 9.—Strip from thigh excised with aponeurosis attached.

present time a very much more radical operation is performed than in the early cases.

Technic.—A long, modified semi-elliptic incision, which includes the skin to be sacrificed, is made on one side of the affected limb. On the outer aspect

of one of the lower extremities, for instance, this incision extends from the crest of the ilium to a point a little below the external malleolus. Then, in order to facilitate wide removal of the subcutaneous fat, the skin is reflected on each side of the incision for a distance of about 6 cm. The skin is then

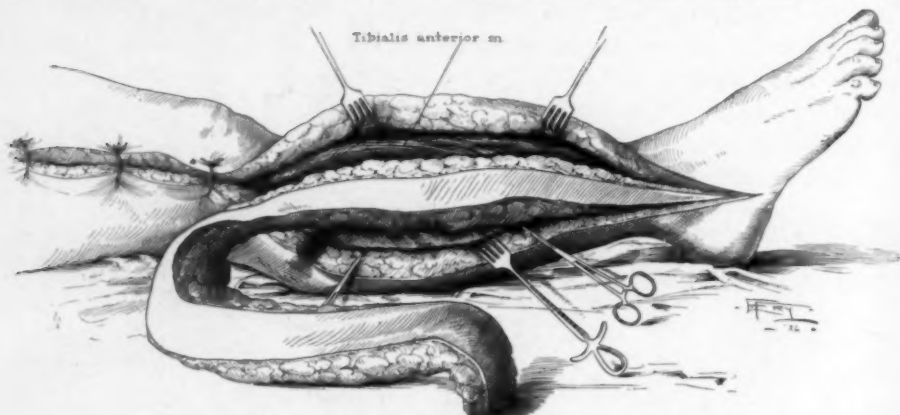


FIG. 10.—Incision in thigh closed and strip ready to be removed.

retracted and underneath each of the edges of reflected skin a long incision is made through the subcutaneous fat down to, and including, the aponeurosis. These incisions are made almost parallel with the original skin incision. Included between them is a quadrilateral piece of subcutaneous fat and aponeurosis. The two incisions through the aponeurosis are then connected at

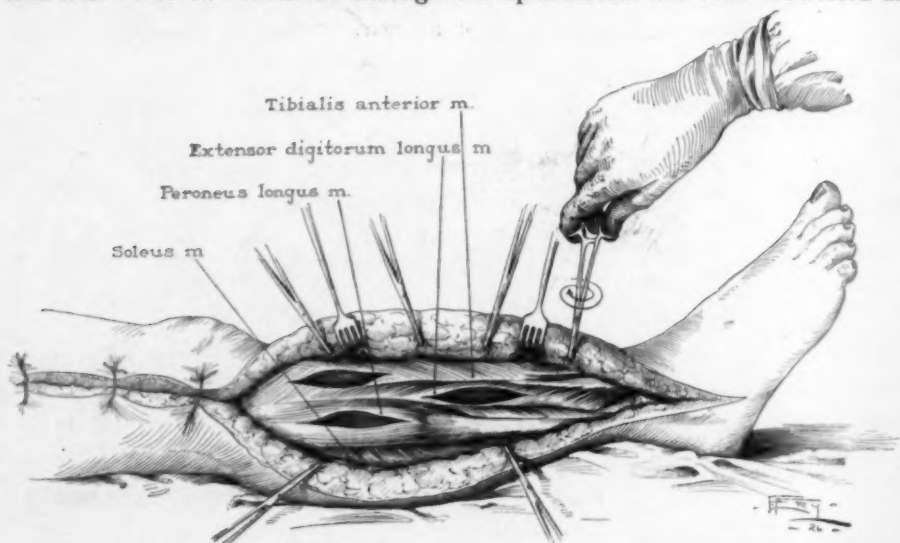


FIG. 11.—Incision in thigh closed, strip removed from leg and slits in muscles.

their ends, so that the tissues to be removed are free except for the attachment of the aponeurosis to the underlying muscles. By traction on these tissues it is easy to dissect the aponeurosis from the muscles throughout the entire length of the limb and to remove in one long piece the skin, subcu-

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taneous fat underneath it and aponeurosis. The skin with the small amount of subcutaneous fat is allowed to drop down on the muscles and the wound is closed with interrupted silkworm sutures without drainage. It is usually necessary to perform a similar operation on the opposite side of the limb (Figs. 7, 8, 9, 10, and 11).

The operation is not devoid of danger as very severe shock often follows a radical operation of this sort. Efforts are made to prevent this, first, by keeping the blood-pressure up as near normal as possible during the pre-operative period, and by the administration of opiates, usually one-quarter grain of morphin, one-half hour before the operation, and by deep ether anæsthesia. Nerve blocking, no doubt, would also help to prevent shock, although I have never used this method. After the operation the patient is immediately treated as though severe shock were present: the head of the bed is lowered, external heat is applied, morphin is administered, and isotonic solution of sodium chloride is given subcutaneously and by rectum. From 5 to 10 minims of a 1 : 1000 solution of epinephrin is also administered shortly after the operation, and repeated each hour for several doses. The period during which shock develops is usually passed after from six to twelve hours.

It is best before the operation to have a distinct understanding with patients as to the result to be expected; they should clearly understand that the operation is an attempt to control a disease which grows progressively worse if left untreated and which will eventually produce tremendous deformity and often in the late stages of the disease result in death through repeated attacks of erysipelas. They should also understand that it will be necessary to use a bandage for an indefinite period after the operation. Should extensive œdema develop after operation, in spite of the bandaging, much benefit is received by an occasional rest in bed with the limb elevated and carefully bandaged.

ON THE USE OF LIPIODOL IN RELATION TO THORACIC SURGERY*

By CARL A. HEDBLUM, M.D.

AND

JEROME R. HEAD, M.D.

OF CHICAGO, ILL.

FROM THE SURGICAL DEPARTMENT OF THE RESEARCH AND EDUCATIONAL HOSPITAL OF THE UNIVERSITY OF ILLINOIS
MEDICAL SCHOOL, AND FROM THE AUGUSTANA HOSPITAL, CHICAGO

OF ALL diagnostic methods that involving the use of the Röntgen-ray is the most important, and has furnished the greatest impetus to the development of thoracic surgery. There have been, however, marked limitations to its usefulness. In bronchiectasis without much fibrosis the röntgenogram may fail to demonstrate the lesion. A pulmonary abscess cavity may be undistinguishable from surrounding pneumonitis or sclerosis. A solitary, multilocular or multiple abscesses of the lung or an empyema cavity may be entirely masked by a diffuse thickening of the pleura. The nature, extent and relations of fistulous opening in the chest wall are perhaps never demonstrable on the ordinary röntgenogram. In the study of such conditions the use of a safe and practical contrast medium, similar in principle to those used in the röntgenological examination of the gastro-intestinal and genito-urinary tracts should therefore be of the greatest value.

The introduction of bismuth paste by Beck was the first step in this direction and has proven very useful in the study of fistulae and of empyema cavities. This method is, however, not without its dangers and is not suitable for intratracheal injection. Chevalier Jackson² in 1918 reported a case in which the right bronchi were outlined röntgenographically by bronchoscopic insufflation of bismuth. In 1920, Lynah³ reported two cases of lung abscess outlined by a similar method. The limitations in the distribution of the powder and the necessity of bronchoscopy in its introduction, however, would probably have prevented the wide adoption of this method even if a safe and practical contrast medium and a simple method for its use had not been found.

Such a medium and method was introduced by Sicard and Forestier.⁴ In 1921 they noticed that a preparation of iodine and oil (lipiodol), developed by Lafay for intramuscular iodine medication, was opaque to the X-ray. They conceived the idea that because of this opacity and the fact that it was entirely non-irritating to the tissues, it might be used to advantage in the radiosopic examination of the various body cavities. After a series of animal experiments, they proceeded to use it on patients, injecting it into the subarachnoid space, the nasal sinuses, the urethra, bladder, kidney pelvis, fistulous tracts, and into the bronchial tree. (See Fig. 1.) Valuable information was obtained from the röntgenogram taken after the injections and in none (save in one case of injection into the cerebral ventricle) were unfavorable complications or signs of irritation noted.

* Read before the Western Surgical Association, October 15, 1926.

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The preparation is 40 per cent. metallic iodine in a base of poppy-seed oil. The iodine is so intimately combined with the oil that it cannot be detected by the ordinary starch test. It is a relatively light oil of a specific gravity of 1.350. It is practically odorless and tasteless, of a light amber color, and is translucent. When exposed to the light for any length of time iodine is set free and the mixture becomes darker. It is then irritating to the tissues.

The iodine is also set free rapidly by the alkaline intestinal juices and consequently if more than a few cubic centimetres are allowed to enter the alimentary tract iodism may result. In all other cavities and tissues the absorption of the oil and the freeing of iodine is so gradual that iodism will not result.



FIG. 1.—Röntgenogram of normal lungs after injection of lipiodol. This patient had a persistent cough and symptoms suggesting the dry type of bronchiectasis.

Its Use in the Different Types of Thoracic Disease.—There are certain types of disease in which the method is especially valuable. First among these should be placed bronchiectasis, and second that group of long-standing suppurative processes in which the whole affected portion of the lung, either because of fibrosis, pleural thickening, or fluid, presents a more or less diffuse clouding and in which the physical findings are similarly masked. (See Figs. 2 and 3.) In some cases of these conditions the clouding is so dense that even the lipiodol does not produce a contrast shadow. In most instances, however, it shows the nature of the lesion where all other methods fail.

Bronchiectasis.—In bronchiectasis one is confronted with a patient who is raising quantities of purulent sputum and yet whose physical examination and X-ray pictures (see Fig. 9) may give little evidence of the lesion. This is partly because uncomplicated bronchiectasis produces few changes that are detectable by the röntgenogram and partly because the lesions, occurring

usually in the lower lobes, may be masked by the shadows of the heart or diaphragm.

To be operable bronchiectasis must be unilateral. It has often been impossible to tell from physical findings and röntgenogram whether both lungs or only one are affected. A few râles in the better lung may mean extensive involvement or may mean nothing at all, and on the other hand we have found that complete absence of physical and röntgenogram signs does not mean that pathology is not present. During the past months we have



FIG. 2.—Röntgenogram after injection of lipiodol, of girl aged eleven years, who had had chronic cough and a small amount of sputum for a year. The plain plate showed merely an area of increased density in the region of the right middle lobe. The physical signs were merely those of consolidation.

made it a routine to make lipiodol injections on both sides.

In considering surgical treatment in unilateral cases, it is important to know the extent and nature of the dilatations, their relations to the diaphragm and hilus, and the presence and location of any large sacculations. (See Figs. 4, 5, 6, 7, 8, 9 and 10.)

One must bear in mind also that in bronchiectasis the sputum is the result of a complication and is not a necessary manifestation of the essential pathology. It is only when the dilated bronchi become the seat of a purulent bronchitis that sputum is produced. Some cases in which bronchiectasis has been demonstrated at necropsy had never had the characteristic cough and

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purulent sputum, others have it only during the winter months and a fairly large per cent. of those who have been studied after the disease was fully developed give a history of having had a longer or shorter free interval following the etiological disease in which a non-productive cough was the only symptom. Bezancon⁵ has called this the dry type of bronchiectasis. One can readily see that in these cases lipiodol plates are the only means of making the diagnosis. If the injection proves eventually to be as innocuous as it now seems it will doubtless be indicated in all patients, especially children, in whom a cough persists after measles, pertussis or pneumonia.

A diagnosis of bronchiectasis has usually been made in these cases only after years of cough and sputum.

Were the diagnosis

made when the process was incipient, before chronic infection and repeated acute attacks had caused extensive pathological changes, much might be accomplished by conservative treatment, especially in children, in whom the ability to repair pulmonary injury is marked. Bronchiectasis may be another disease in which early diagnosis and intelligent prophylaxis is the key to successful treatment.

Lung Abscess.—Most cases of solitary lung abscess are readily localized by the physical findings and röntgenogram. A complicating bronchiectasis

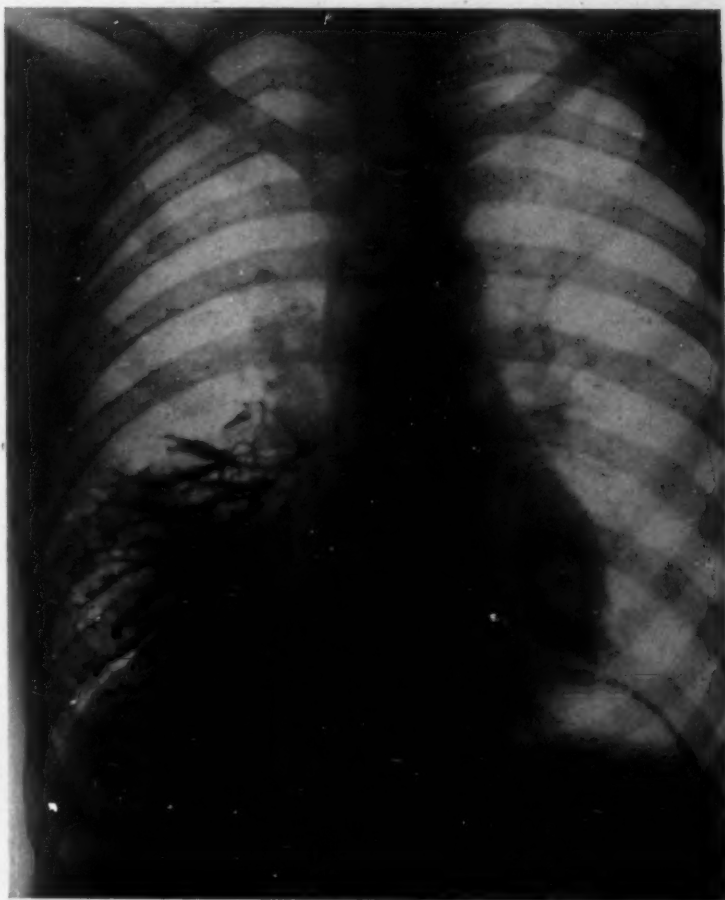


FIG. 3.—Röntgenogram after the injection of lipiodol, of boy aged seventeen years, who for three years had had the classical syndrome of bronchiectasis, raising six to eight ounces of purulent sputum each twenty-four hours.

may, however, be entirely overlooked. Two of our patients had cough and sputum persistent after drainage of what seemed simple abscesses and subsequent examination after lipiodol injection showed in each a complicating bronchiectasis. Ballon⁶ has already noted the frequent incidence of bronchiectasis with abscess.

In many cases of abscess a diffuse fibrosis or pleural thickening mask

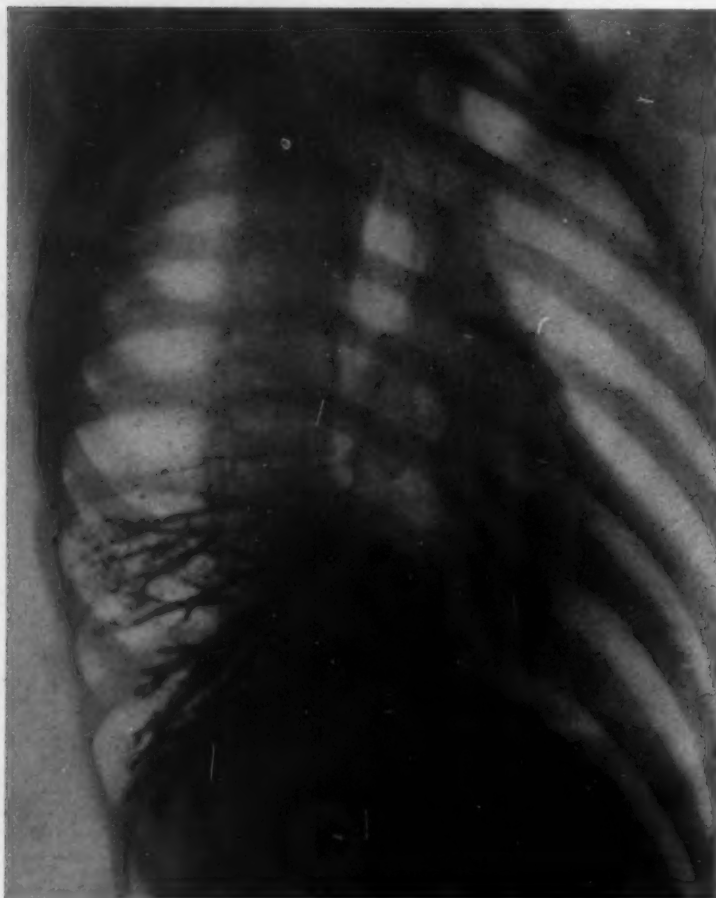


FIG. 4.—Röntgenogram of same patient as Fig. 3. This patient was rendered cough and sputum free by avulsion of the right phrenic nerve.

both the physical and the X-ray findings. In other cases for which the term suppurative pneumonitis is perhaps the most descriptive term, the lesion is definitely localizable, but at operation the whole diseased portion of the lung is found to be honey-combed with multiple small abscesses. The lipiodol roentgenogram is about the only means of differentiating these cases. In the first mentioned group drainage is indicated,

in the latter cauterization. Ballon has noted that unless care is taken to empty the abscess by posture before the injection, the oil will often not flow into it and the plates will merely show a bronchus ending blindly. He explains this on the basis that in the abscess the emptying is by overflow, not by active expulsion as in bronchiectasis. In some cases bronchoscopic aspiration is probably necessary for evacuation of the pus. The lipiodol can then be instilled through the bronchoscope.

Empyema.—There is no way of determining accurately the size and location of a single empyema cavity and the presence of multiple communicating

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cavities except by röntgenogram after the injection of a contrast medium. We have used 12 per cent. sodium iodide solution. It is irritating, however, to the bronchial mucous membrane and so cannot be used when a fistula is present. When a bronchial fistula was suspected, we have injected a dye into the cavity and by recovering some of it in the sputum verified its presence, but it has been impossible to outline the cavity, locate the fistula or determine its size. In these cases lipiodol is of very great value, affording information on all of these points.

Fistulae of Chest

Wall.—Not infrequently one encounters cases where the

complaint and the most obvious physical finding is a sinus in the chest wall. The sinus may be due to empyema, a narrow pleuro-cutaneous sinus, bronchocutaneous fistula, or osteomyelitis of a rib. Heretofore we investigated these, first by injecting a dye, then, if no bronchial fistula was found, by injecting sodium iodide or bismuth in oil. If lipiodol is injected instead the nature and extent of the sinus may be demonstrated by the röntgenogram without any danger of un-

toward results from bronchial irrigation, or, in case bismuth is used, from its absorption or from the possibility of fatal cerebral manifestations.

Pulmonary Tuberculosis.—There has been considerable discussion concerning the possible harmfulness of injecting lipiodol into the bronchi in pulmonary tuberculosis. Many have hesitated to use it because of the long-established belief that iodine breaks down the encapsulating fibrous tissue

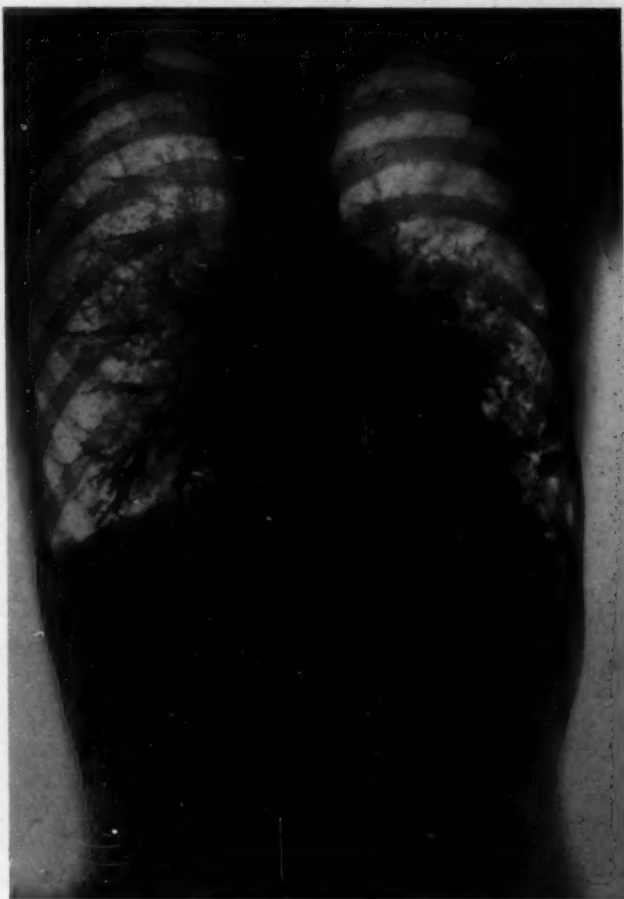


FIG. 5.—Röntgenogram, after the injection of lipiodol, of girl aged nine years, who for three years had had the classical symptoms of bronchiectasis. The plain plate showed no pathology save slight peribronchial infiltration.

and activates the tuberculous process. It seems generally agreed that the soft rapidly progressive types of the disease are made worse by iodine. Whether or not the method is entirely harmless in the more fibroid type remains to be determined. We have used it in three instances where the

information to be derived from it seemed especially desirable.

In most cases of pulmonary tuberculosis in which surgical treatment is considered, the added information which one might gain from lipiodol plates would ordinarily have but little significance. In these cases the question is as to whether or not pulmo-

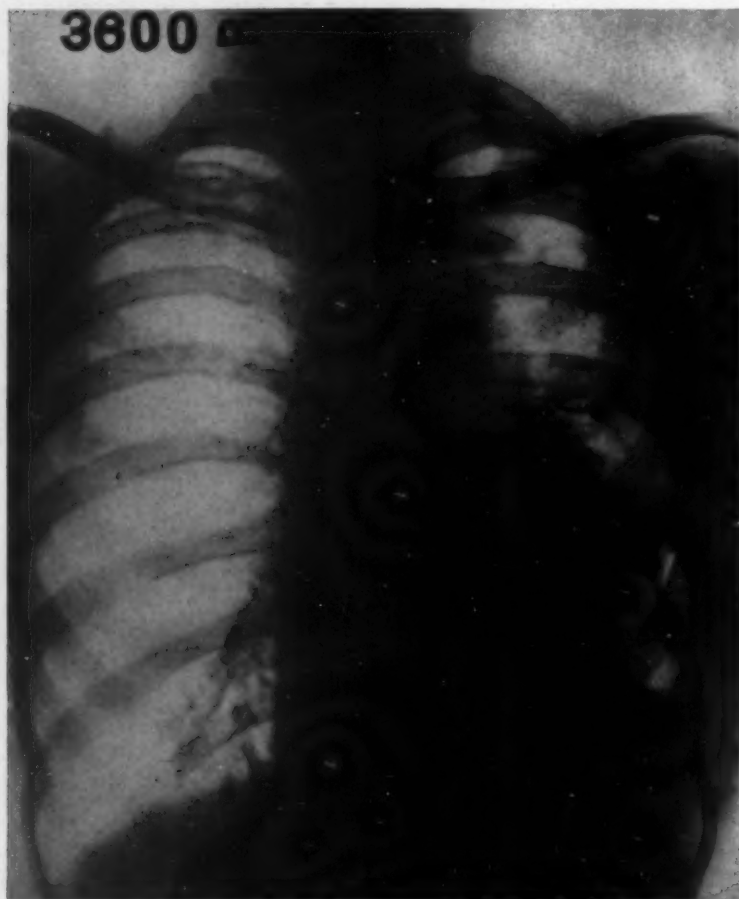


FIG. 6.—Multiple empyema cavities. Röntgenogram taken after the injection of lipiodol into a draining sinus in the chest wall.

nary collapse is indicated and if the other lung is sound one would ordinarily proceed with the operation regardless of the extent of the cavities in the lung involved. The method may possibly be of some value in some cases in demonstrating the nature and extent of a lesion in the better lung and so aid in the selection of cases for operation.

Intra-thoracic Neoplasms.—We have used lipiodol in one case of intra-thoracic neoplasm. The ordinary röntgenogram showed a sharply outlined tumor extending into the lung field from the hilus region. The problem was whether or not the growth invaded the pulmonary tissue and what its relation to the bronchus might be. The plate furnished definite information on these points.

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In Estimating the Results of Operation.—It has already been stated that the method is valuable in judging the results of drainage, cautery, and collapse operations. It enables one to determine between several stage operations, for abscess and for bronchiectasis, just how much has already been accomplished and what further is indicated. Ordinary röntgenographic findings after operation are usually so abnormal and obscured

by pleural thickening that they afford little information. The physical signs are similarly masked, and the chief symptom, the amount of sputum, is often misleading. After cauterization it is difficult to determine the amount of pus evacuated because of an associated profuse watery bronchorrhoea. In bronchiectasis there may be a reduction in the sputum out of proportion to the degree of collapse of the cavities. We have had several cases in which the improvement immediately after the operation was much greater than that which became permanent. In these cases subsequent lipiodol plates showed considerable cavities still uncollapsed.

Certain aspects of the subject merit discussion. These are, in the order of their importance, (1) the question of its innocuousness, (2) the interpretation of the plates, and (3) the method of making the injection.



FIG. 7.—Röntgenogram, after the injection of lipiodol, of patient who had persistent cough and sputum after external drainage of a lung abscess. The plates showed nothing to indicate the cause. Note the residual bronchiectasis in the region of the healed abscess.

The Question of Possible Harmful Effects from Lipiodol.—(1) On first consideration the introduction of so large an amount of foreign substance into the finer ramifications of the bronchial tree seems a radical procedure. One might anticipate a severe immediate reaction, or that later complications in the nature of abscess, bronchiectasis or fibrosis might result. At present



FIG. 8.—Multiple empyema cavities. Röntgenogram taken after the injection of lipiodol into a draining sinus in the chest wall.

all that can be said is that so far none have been observed. The patients do not cough during the injection. In the course of ten or fifteen minutes they have what is for most of them a normal coughing spell during which they raise most of the oil. This spell is not severe or protracted. A small amount of the oil remains in the alveoli and is gradually absorbed over the course of weeks or months. We have had patients in case of whom this oil had disappeared entirely in a week, in others it was still present in part after several months. It is expelled from abnormal pulmonary cavities more readily than from the terminal bronchi of the normal lung.

We have not used the oil in a patient who did not have a cough before the injection. In those patients in case of whom we have used it, and we have often injected large areas of normal lung, the preëxistent cough has either lessened or remained unchanged. In none have we been able to note any ill effects. At the present time we have under observation a series of

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dogs in whom we have made injections. These will be autopsied at intervals and the lungs examined grossly and microscopically.

Interpretation of Röntgenograms.—(2) As yet but little can be said on the interpretation of the plates. In many of them the findings are definite, but it is probable that interpretation is not as simple as it may seem. Sergeant has noted sacculation in emphysema which are with difficulty distinguished from those in

bronchiectasis. Ballon has called attention to the occasional failure of filling of an abscess.

There is always the chance that the oil will not flow into the affected area. One factor which will always have to be considered is the fact that the picture varies with the amount of oil injected. If the patient coughs before the exposure there results a rather characteristic picture.

Compared with the normal it is much

as if one had brushed his hand across a finely drawn etching while it was still wet—often such pictures are entirely unintelligible.

Methods of Making the Injection.—There are four methods of making the injections—the supraglottic, the transglottic, the subglottic, and the bronchoscopic. In the first the pharynx and base of the tongue are anæsthetized, the tongue pulled forward and the oil dropped over the base of it as the patient inspires.



FIG. 9.—Unilateral pulmonary tuberculosis. Repeated hæmoptysis. Extra-pleural thoracoplasty. The patient was greatly improved by thoracoplasty, but still had an occasional hæmoptysis. Röntgenogram taken after the injection of lipiodol. There is stenosis of the right main bronchus. Since this picture was taken a pneumolysis has been performed following which the hemorrhages have practically ceased.

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In the transglottic method, after careful cocainization of the pharynx and larynx, the oil is injected through a curved cannula which, under direction of the laryngoscopic mirror, is inserted between the vocal cords. This requires special training on the part of the operator and considerable coöperation from the patient. It cannot be used in children.

The injection of the oil through the bronchoscope requires no explanation.

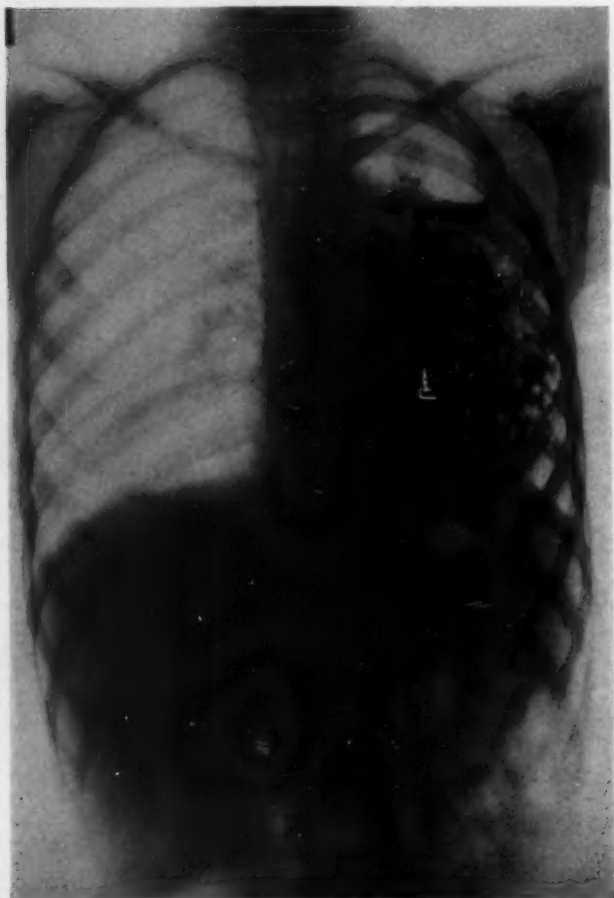


FIG. 10.—Pulmonary tuberculosis, apical pneumothorax with bronchial fistula. Röntgenograms taken after the injection of lipiodol.

We have had experience only with the subglottic method. In this a curved cannula is inserted through the crico-thyroid membrane and the oil injected directly into the trachea. The instruments and technic were developed by Rosenthal⁸ for tracheal medication and were later adopted for the present purpose by Forestier, Sergeant⁹ and Armand-Delille.¹⁰ The instruments here described were modelled after these and were made by V. Mueller and Co. They consist of a 30-c.c. Record syringe (*a*) fitted with a threaded piston stem, a two-inch connection of catheter rubber (*b*) with adapters, and a curved tracheal trocar and cannula (*c*). The

screw mechanism is necessary because the oil, being relatively viscid, is with difficulty forced out by direct pressure. The catheter connecting piece permits movement of the cannula on swallowing or coughing without movement of the syringe. The curved cannula (Armand-Delille¹⁰) is used rather than a straight or curved needle. (Sergeant and Cottenot⁹), because it is less likely to injure the posterior tracheal wall and is better tolerated than a sharp instrument. The cannula is made in two sizes, one for children and the other for adults.

The technic of the procedure is as follows:

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One hour before the injection to control the cough reflex the patient is given from $\frac{1}{2}$ to 1 grain of codeine hypodermically. About three-quarters of an hour later he is directed to bend over and rid himself of all accumulated sputum. He is then seated in a chair facing the operator, his neck painted with iodine and with a fine hypodermic needle and 3 per cent. novocaine a dermal wheal is raised in the midline just above the cricoid. The infiltration is then carried to the level of the trachea and with a slightly larger needle the trachea punctured and 4 to 5 c.c. of the 3 per cent. novocaine solution injected. This usually causes coughing and it may be necessary to draw out the needle and re-insert it two or three times before the whole amount is instilled. While the novocaine is taking effect a tiny incision is made just through the skin with a narrow-bladed knife, and the lipiodol, which has been placed in a basin of warm water to bring it to the body temperature and decrease its viscosity, is poured into the syringe. Then, with the forefinger of the left hand acting as a guide on the cricoid, the trocar and cannula are inserted through the skin incision and into the trachea. The trocar is removed and with an assistant steadying the cannula the syringe is fitted to it and the injection made. Before starting it the patient is told that coughing will spoil the result and is asked to try very hard not to cough.

The position of the patient during the injection is very important. Gravity determines the portion of the bronchial tree into which the lipiodol flows. With the patient upright, most of the oil will go into the left lower bronchus. This cannot be counted upon, however. In case one wishes to inject the left lower bronchus the body should be inclined to the left at an angle of about 30 degrees. If it is desired to inject the right lower bronchus, the inclination should be to the right side. Both lower lobes can be filled by injecting part of the oil while the patient is leaning to the right, the remainder while he is leaning to the left. To fill the middle lobe the injection is made with the patient recumbent upon the affected side. Examination of an apex is the most difficult. In some instances one can be filled with the patient in the recumbent lateral position. It can be reached more certainly if immediately after the injection of the oil the patient is held over the edge of the table in the lateral position and with the head slightly lower than the hips.

The amount of oil injected is usually 20 c.c. Forestier mentions having administered as much as 60 c.c. at one time. What the maximum amount of lipiodal that may be injected with safety at one time may be, remains to be determined. Not infrequently one is able to outline the bronchial tree of one lobe with injection of no more than 20 to 30 c.c. and without producing symptoms.

The X-rays must be taken immediately after the injection. While usually the patient does not begin to cough for 10 to 15 minutes, there is always danger that he may do so, and consequently the sooner the picture can be taken the less are the chances of failure from this source. It is our custom to take stereoscopic plates of the chest and then one oblique plate. The

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oblique position often throws into relief shadows which are otherwise obscured by the heart or diaphragm.

BIBLIOGRAPHY

- ¹ Beck, E. G.: Fistulous Tracts, Tuberculous Sinuses, and Abscess Cavities: A New Method of Diagnosis and Treatment by Bismuth Paste. *J. A. M. A.*, 1908, vol. 1, p. 867.
- ² Jackson, Chevalier: The Bronchial Tree: Its Study by Insufflation of Opaque Substances in the Living. *Am. J. of Roentg.*, 1918, vol. v, p. 454.
- ³ Lynah: Lung Mapping by Injection of Bismuth Mixtures in the Living. *New York Med. J.*, 1921, vol. cxiv, p. 82.
- ⁴ Sicard, and Forestier, J.: Iodized Oil as Contrast Medium in Radioscopy, *Bull. et mem. Soc. med. d. hop. de Paris*, 1922, vol. xlvi, p. 463.
- ⁵ Bezancon: The Dry Hæmoptysic Type of Bronchiectasis. *Bull. Acad. d. Med. de Paris*, 1924, vol. xci, p. 100.
- ⁶ Ballou, D. H.: Lipiodol in the Diagnosis of Broncho-pulmonary Lesions by Bronchoscopic Method. *Arch. Otolaryngol*, 1926, vol. iii, p. 403.
- ⁷ Forestier, J., Sicard, J. A., and Fabre: Elimination of Iodine in the Urine. *Bull. et mem. Soc. med. d. hop. de Paris*, 1923, vol. xlvii, p. 315.
- ⁸ Rosenthal, G.: The Technic of Intererico-thyroid Injections. *Paris Med.*, 1920, vol. x, p. 521.
- ⁹ Sergent, E., and Cottenot, P.: Cited by Armand-Delille.¹⁰
- ¹⁰ Armand-Delille, Duhamel et Marty: Iodized Oil in Roentgen Diagnosis of Bronchiectasis. *Presse Medical*, 1924, vol. xxxii, p. 421.

OBSERVATIONS ON PEPTIC ULCER*

I. A METHOD OF PRODUCING CHRONIC GASTRIC ULCER:

A CONSIDERATION OF ETIOLOGY

By CHARLES BRUCE MORTON, M.D.

OF ROCHESTER, MINN.

FELLOW IN SURGERY, DIVISION OF EXPERIMENTAL SURGERY AND PATHOLOGY, THE MAYO FOUNDATION

ULCERS produced in the stomachs of dogs by the methods herein described have in general the same characteristics as the peptic ulcer found in the stomach and duodenum of man; they are subacute or chronic, show little or no tendency to heal, and are inclined to perforate. They also appear to have a selective affinity for the parts of the stomach that are shown clinically to harbor peptic ulcers most frequently. It would seem, therefore, that the data obtained from the experimental study of such ulcer might throw some light on the etiology.

As a background for such a study, the literature was reviewed, particular attention being paid to the experimental production of ulcers and its relation to the etiology of the disease. So much has been written, however, concerning these two phases of the problem that it is impossible in one paper to do more than outline the work that has been accomplished. Bolton, Greggio, Ivy, Butsch, Durante, Rosenow and others have reviewed the literature comprehensively. I shall refer the reader to their work for many historical points too detailed to be considered here.

While ulcer was apparently recognized as long ago as the time of Celsus, and an undoubted case, described by Johann Bauhin in the sixteenth century, was cited by Lebert in 1878, the postmortem appearances and clinical manifestations of the disease were first accurately described by Mathew Baillie in 1818. To Cruveilhier, however, writing a few years later, belongs the credit of having first thoroughly investigated the subject and described in detail the morbid appearances, complications and sequelæ, clinical history, and rational treatment of the disease.

It was in 1853 that Virchow advanced his hypothesis that the origin of ulcer lay in circulatory changes; since then it has been the subject of much clinical and experimental study. Numerous other hypotheses have been advanced but their very multiplicity demonstrates that there must be several etiologic factors in the production of ulcer, no one of which can be exclusively incriminated.

The importance of peptic ulcer to-day, not only as a problem in treatment which confronts the physician and surgeon, but also as an economic problem, is made more apparent by the evidence of statistics. Brinton, in 1864, found that gastric ulcer was present in 5 per cent. of all necropsy subjects. Fenwick, in 1900, stated, from an analysis of 825 cases, that ulcer of the stomach was found oftenest in the third and fifth decades of life. Bolton, from a com-

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parison of several groups of statistics, concluded that females were more susceptible to ulcer than males. W. J. Mayo, however, in 1911, from statistics of 1000 at operation, found ulcer of the stomach or duodenum or both in 255 women and 745 men. More recent statistics by Robertson and Hargis, from an analysis of 2000 necropsy reports, showed an occurrence of ulcer or scars of ulcer totalling 18.9 per cent. Of these, 7.05 per cent. were gastric, 11.85 per cent. were duodenal, and 7 per cent. affected both stomach and duodenum. In this series the ratio of males to females was three to one, verifying the operation statistics of W. J. Mayo.

Ulcer then is a relatively common disease, is apparently on the increase, and is encountered most frequently in the most active and productive period of life. It is very important to distinguish between the acute and chronic types or stages. They are so different in characteristics and properties that it may be well to compare them briefly.

An acute ulcer, or an ulcer in the acute stage, has grossly a definitely acute and fresh appearance. It gives the impression of an area having been dissolved out rapidly and cleanly, leaving usually a funnel-shaped depression of variable size, depending on the agent that has produced the lesion. The shape also is variable, depending on the mode of production, although most of the lesions are roughly circular or elliptical. Microscopically the ulcer is sharply defined, the tissue surrounding the acute lesion being, for the most part, healthy and normal. The epithelium at the edge is healthy looking and, almost as soon as the erosive process that caused the acute ulcer has ceased to act, the epithelial cells begin to grow out and repair the gap in the mucosa. The acute lesion tends to heal rapidly, and everywhere evidences of this tendency are present.

A chronic ulcer has a very different appearance. It has a sluggish, chronic look; the base is dirty, necrotic, and indurated. The edges are thick and raised and tend, like the edges of a bank that has been undermined by the gnawing of a swift current, to overhang. The surrounding mucosa usually shows chronic inflammation of varying degrees that is covered with thick and tenacious mucus. Size and shape are variable, although the medium-sized, punched-out, circular or elliptical lesion is the rule. Microscopically the ulcer is equally characteristic. The crater is often cone-shaped with the apex toward the mucosal surface; the mucosa is overhanging and stops abruptly. Signs of epithelial proliferation at the edge, if present at all, are meagre and limited. The submucosa is definitely, sometimes markedly thickened, having in section the shape of a wedge with the thick part pointing toward the crater and the point gradually tapering off and losing itself in the normal submucosa distal to the ulcer. There is marked cellular infiltration of the surrounding tissue, with necrosis of that immediately adjacent to the crater. The depth of the ulcer is variable and the base may even be formed by another organ if the ulcer has eroded entirely through the gastric wall. The chronic lesion not only shows absence of healing characteristics, but often shows evidence of a slow process of extension.

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These are the two extremes of acute and chronic lesions, but in between are lesions that exhibit, more or less, the characteristics of both. They are the subacute ulcer which probably represents the transition from the acute to the chronic lesion. Most observers agree fairly well that chronic peptic ulcer very probably has its origin in an acute ulcer. Bolton's hypothesis is that some unknown factor initially damages the cells of the gastric mucosa and so reduces the normal powers of resistance that autodigestion then takes place, giving rise to an acute ulcer. He believes that the chronicity is dependent on some secondary factor, such as infection of the crater and margins.

Acute ulcer of the stomach occurs not only spontaneously in certain conditions (for the most part the acute infections, fevers and toxæmias), but can be produced experimentally in many ways. Butsch, Greggio and Bolton have described the methods in more or less detail and have included the references to original papers. Greggio has grouped the methods of producing ulcer as follows:

1. Certain drugs, poisons, irritants and toxins by general or local injection or by ingestion; the excision of certain special organs: the adrenals, thyroid, liver and so forth.
2. Changes in the blood supply of the stomach caused by injecting emboli, coagulants and so forth into the local or general circulation, by ligating certain vessels or groups of vessels, or by producing retrograde emboli or thrombi by ligating or injuring vessels or groups of vessels having to do with gastric circulation.
3. Changes in the composition of the blood brought about by the administration of pyrogallol acid, pyrocin and so forth to produce anæmia, and often combined with trauma to the gastric wall or its nerve supply.
4. Autodigestion caused by isolation of gastric pouches by certain methods; autodigestion caused by experimental pyloric stenosis, hyperchlorhydria, pyloric insufficiency with reflux of pancreatic juice, and other means of reducing the acids of the stomach. Injection of mucosal extracts, or local injury, together with section of nerves or ligation of vessels.
5. Local trauma to gastric mucosa by ingestion of foreign bodies or by caustics, cold or heat, mechanical injury, excision of mucosa and so forth, combined with various other procedures such as ligation of vessels, local infection of traumatized area, ingestion of hydrochloric acid to produce hyperchlorhydria, injections to destroy antipepsin, suture of rings to gastric wall around traumatized area to prevent shrinkage of the lesion by muscular contraction.
6. Infection by injecting into the local or general circulation or into the peritoneum bacteria of various sorts or their toxins, or in some cases by administering these bacteria by mouth; use of local trauma to the mucosa or injury, interference with the nerve supply or blood supply in conjunction with these means of infection.
7. Injury or section of tracts in the central or peripheral nervous system to upset the nervous mechanism controlling the stomach and the function of

other digestive glands and organs; nerve injury combined with infection, trauma, circulatory changes, experimental anæmia, and other methods.

8. Local injections of adrenalin, formalin, gastrotoxin, silver nitrate, chloral, neurin or cold or hot solutions into the gastric wall or vessels.

Many modifications and combinations of methods have been used, almost any of which have produced some type of acute lesion, varying from small hemorrhages into the mucosa to extensive erosions involving a large part of the stomach.

The means of inducing chronic ulcer in animals experimentally are as few as those of inducing acute ulcer are numerous. Mann goes so far as to say that chronic peptic ulcers appear to have never been consistently produced experimentally in the gastric mucosa by any method.

Acute ulcers, which under normal conditions and in spite of most experimental conditions heal readily, have in some cases been retarded in healing. A few investigators have been able to induce lesions in the stomach or duodenum of animals that are similar, in some respects, to the chronic peptic ulcer found in the stomach and duodenum of man. Bolton and Friedman and Hamberger, by producing partial pyloric stenosis operatively, caused a delay in the healing of acute ulcers induced by gastrotoxin. Ivy was able, in gastric pouches of pyloric mucosa, to cause delay in healing of acute ulcers by frequently rubbing their surface with cotton and bread crumbs. Turck produced a few perforating ulcers of the stomach by feeding cultures of *bacillus coli*, but these ulcers were more acute than chronic.

Greggio by section of the vagi induced gastric ulcer in a few instances which had some characteristics of chronicity. Vedova and Durante produced so-called chronic and acute ulcers in the stomach by resection of the splanchnic nerves. Durante asserted that the integrity of the sympathetic nervous system, controlling as it does circulation, secretion and profound sensibility of the stomach, is necessary to the life of the gastric cell. Recently Bedarida by injecting neurin, a specific paralyzer of motor nerve terminals and the sensory secretory plexus in the submucosa, obtained neurotrophic ulcers in the stomachs of rabbits.

Ivy in a few cases found ulcers after gastroduodenostomy but thought they were due to the malnutrition of the animal after operation. Dott and Lim, by gastro-enterostomy and pyloric exclusion, and Exalto, by a modified "Y" operation, produced chronic types of ulcer in the jejunum. Kehrer reported that apparent subacute gastric and duodenal ulcers had been induced in dogs in some instances by the diversion of the bile and pancreatic juices into the ileum.

Dragstedt and Vaughan, after producing acute ulcers in the stomach by injecting silver nitrate into the mucosa and then putting loops of non-absorbable suture material in the gastric wall at the points of injury, were able to make the ulcers persist for three or four months and assume some characteristics of chronicity.

Rosenow, by the intravenous injection of streptococci with specific powers

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of localization, produced ulcers in the stomach and duodenum of animals that in some respects resemble the ulcers found in the stomach and duodenum of man. Recently Hoffman has produced similar lesions by the use of a similar technic, although his organisms were short bacilli.

Mann and Williamson produced ulcers in the duodenum and jejunum of dogs by shunting the alkaline secretions into the lower ileum where they could not serve to neutralize the gastric juice. The ulcers produced in this manner occurred in more than 90 per cent. of experiments, and are probably more like the clinical peptic ulcer than any experimental lesion which has yet been produced.

Since it is so difficult to produce experimentally in the stomach an ulcer that does not heal, a short consideration of the healing process seems not amiss. Pavy, Ziemmsen, Leube, Crämer, Quincke and Daettwyler, Cohnheim, Griffini and Vassale, Matthes, Bolton, Ivy, Mann, and others have studied the healing of ulcers. Ivy divided the process into two stages: the first tended to lessen mechanically the area to be covered by mucosa and to prepare the field for healing; the second, characterized by the actual covering of the crater with epithelium and the growth of the glands, gave the area a true mucosal covering.

More recently Mann has studied the healing process in detail from a large number of ulcers produced by this method of "surgical duodenal drainage." He has observed that the base of the lesion is first cleaned; slough separates and a protecting coat of serum and coagulum forms over healthy granulations. These processes ordinarily take about four days. Simultaneously the mucosa begins to grow out from the edges as a thin layer of flat epithelial cells. The edges of the mucosa tend to overhang and the granulations to push up in the centre so that the growing edge of mucosa is protected in the resulting depression. This initial stage, which has the effect of also decreasing the area to be healed over, takes place in about ten days. Once initiated, the healing, if undisturbed, is rapid. In twenty days three-fourths or more of the base is covered with epithelium, and in thirty days the lesion is usually healed entirely. The scarring is in many cases hardly noticeable.

Recently Kennedy and Caylor in clinical duodenal and gastric ulcers, respectively, have found healing lesions that correspond strikingly to the healing process in experimental peptic ulcer as described by Mann.

But, as Bolton points out, any agent which retards this healing process causes scarring, thickening, and induration of the base and gives the ulcer a punched-out appearance. The submucosa tends to thicken, approaching the wedge-like form seen in chronic ulcers.

Although a few investigators have been able to cause delay in healing of acute ulcers and others have been able to produce experimentally, ulcers that have some characteristics of chronicity, the problem of the etiology of peptic ulcer is still on rather a hypothetical basis. It has been the subject of many hypotheses since the time when Virchow, in 1853, suggested that ulcer was

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probably due to obstruction of the circulation by thrombotic plugs in the vessels. It has since been shown that the thrombi are probably secondary to, and arise from, the infected ulcer. Many observers have tried in various ways to interfere with the circulation of the stomach or parts of it, but ulcers have been produced only when the very terminal vessels have been plugged. Furthermore, such ulcers do not manifest the characteristics of the chronic peptic ulcer.

The numerous other theories advanced to explain peptic ulcer have been grouped by Greggio and may be outlined as follows:

1. Local changes in the gastric mucosa caused by irritants such as alcohol, drugs and so forth; gastritis; lesions resulting from acute catarrhal processes, and from disturbed digestion.

2. Circulatory lesions of the gastric wall as a result of thrombosis, embolism, hemorrhagic infarct, stasis, ischaemia, injury to vasolymphatics, vascular spasm, reflex or nervous spasm or anatomic anomalies of arteries or their distribution.

3. Alterations in the composition of the blood as found in such conditions as chlorosis, anaemia, haemoglobinemia, decreased alkalinity of the blood, changes in the local or general antipepsin content of the blood, hemorrhagic diathesis from functional disease of the liver, and changes in the blood as a result of skin burns.

4. Autodigestion as the result of gastric stasis, changes in acid-pepsin secretion, changes in blood supply or nerve supply of the mucosa, lack of anti-pepsin, changes in the composition of the blood, inflammation of underlying lymph follicles, or islands of intestinal mucosal cells in the gastric mucosa.

5. Trauma from ingestion of foreign bodies, blows on the epigastrium, long-continued pressure over the epigastrium from tight clothing and so forth, and pressure of tumors.

6. Infection such as that resulting from septic emboli, from infection in the blood in local or general septic processes, from local infection of the mucosa by ingested bacteria or their toxins.

7. Disturbance of the nervous control of the stomach causing a neurotrophic lesion or one that is due to the resultant changes in secretory, sensory-motor, and vasomotor functions of the stomach.

8. Certain constitutional diseases, such as certain of the blood dyscrasias, sepsis, tuberculosis, dysfunctions of endocrine gland and so forth.

While these theories may explain certain individual cases of ulcer, they do not solve the real problem, the chronicity of peptic ulcer.

METHOD OF EXPERIMENTATION

In the study of experimental ulcer two facts seemed to stand out: First, all acute lesions produced in the normal stomach healed very readily; and second, the method of surgical duodenal drainage described by Mann and Williamson produced ulcers in the jejunum in almost 100 per cent. of experi-

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ments. I then conceived the idea of making acute lesions in the stomach and in addition performing surgical duodenal drainage in order to determine whether the stomach would still heal with its usual ease. Dogs were used in all experiments and for the operative procedures ether anaesthesia and aseptic technic were employed.

No rubber-covered or other intestinal clamps, and no unabsorbable sutures were used in any of the operations, all of which were performed by me.

The stomach was opened anteriorly by means of a small incision. In selected portions of the stomach four areas of mucosa, caught and lifted up with Allis forceps, were excised with sharp scissors. In this procedure the mucosa and part of the submucosa (and in some experiments the greater part of the muscularis) were excised cleanly; thus four circular areas about 2 cm. in diameter were denuded of mucosa. The excised areas were situated as follows: The first and second were on the lesser and greater curva-

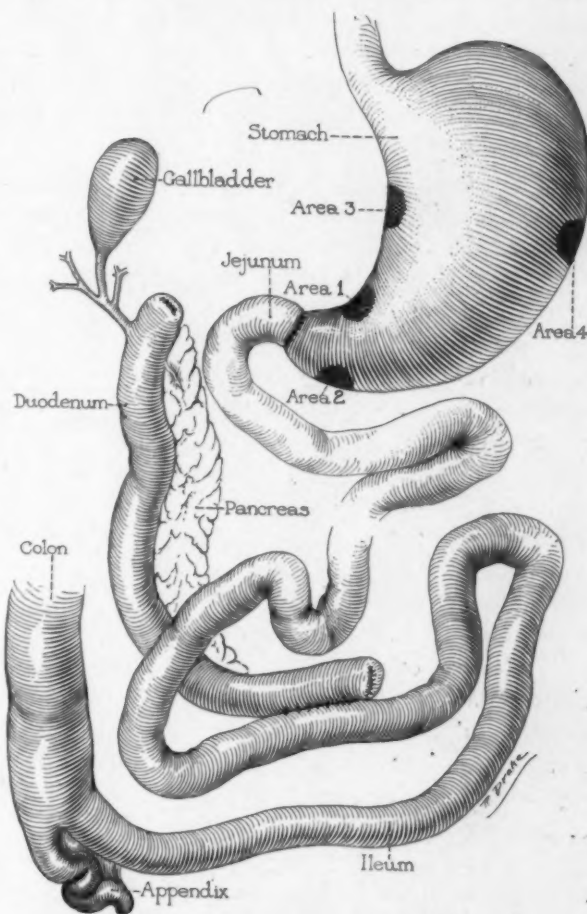


FIG. 1.—Diagram of operative procedures. Stomach shows areas of mucosa excised in experiments of Group 1. Gastro-intestinal tract shows method of surgical duodenal drainage in Group 2. Diagram, as a whole, shows the entire operative procedures in Groups 3 and 4.

tures, respectively, about 2 or 3 cm. from the pylorus; the third was midway along the lesser curvature and the fourth midway along the greater curvature (Fig. 1). Hemorrhage was sometimes profuse for a few moments, but always stopped spontaneously. In no case was any suture or ligature applied to vessels in these areas and no case of secondary hemorrhage was encountered. In a few cases similar lesions were made in the duodenum.

After the incision in the stomach had been closed, the operation for surgical duodenal drainage was performed in certain cases as described by Mann and Williamson. Briefly, this consisted in severing the pylorus and closing the distal end, severing the first part of the jejunum, closing the

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proximal portion of it, and suturing the distal portion to the cut end of pylorus by end-to-end anastomosis. By this arrangement the place of the duodenum was taken by the jejunum, and the duodenum, together with a small portion of the adjacent upper jejunum, was left as a closed segment of gut. To provide this an outlet the distal end was drained into the ileum by side-to-side anastomosis. It was found most satisfactory to make this anastomosis between 25 and 50 cm. from the cæcum (Fig. 1). Following this the omentum was used to cover the sites of anastomosis and the abdomen was closed.

The operative technic was soon mastered and proved very satisfactory in that the procedures could be quickly carried out and practically all the animals survived the operation.

The duodenum had thus been anatomically replaced by the first portion of the jejunum. The duodenum had been drained, however, into the ileum at a point which, although too distant from the stomach to permit of the possibility of regurgitation of its alkaline contents into the pyloric region, nevertheless permitted the duodenal secretions, mixed with bile and pancreatic juice, to carry out to some extent their essential part in the digestive process. The first portion of the jejunum, having been anastomosed to the stomach, now occupied the position normally occupied by the duodenum. There were four areas unprotected by mucosa on the internal surface of the stomach. The pylorus had been severed and the duodenum moved, so that not only had the emptying mechanism at the pylorus been upset, but the presence and regurgitation of alkaline secretions into the stomach had been precluded.

Following operation the animals were given the usual care. Food consisted of a regular mixed diet with the addition of milk and syrup. It has been found that milk and syrup, because of their easy assimilability, aid materially in keeping up the animal's state of nutrition. As a rule the nutrition was maintained fairly well up to the time when jejunal or gastric ulcer or both appeared and became definitely chronic.

The experiments were divided into four groups, the first two serving as controls on the others. In the first group areas of mucosa, or in some cases both mucosa and muscularis, were excised from the normal stomach or duodenum and the continuity of the gastro-intestinal tract left intact. In the second group the stomach was undisturbed and the operation for surgical duodenal drainage was performed. In the third group areas of gastric mucosa were excised and at the same time the operation for surgical duodenal drainage was performed. In the fourth group the operation for surgical duodenal drainage was performed and after an interval of two weeks the usual four areas of gastric mucosa were excised.

RESULTS

Group 1.—In this group (simple excision of gastric or duodenal mucosa) there were eight experiments. The lesions made at operation were examined at intervals of from eight to fifteen days, either after the animal had been

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killed under anaesthesia or the portion of the tract containing the lesions had been resected. In all cases the lesions which had been made at operation healed quickly and readily. This was true of both the suture line in the anterior wall of the stomach and four areas which had been denuded of mucosa. It was especially noted that very soon after the lesion had been produced the muscular contraction of the gastric wall in that zone produced

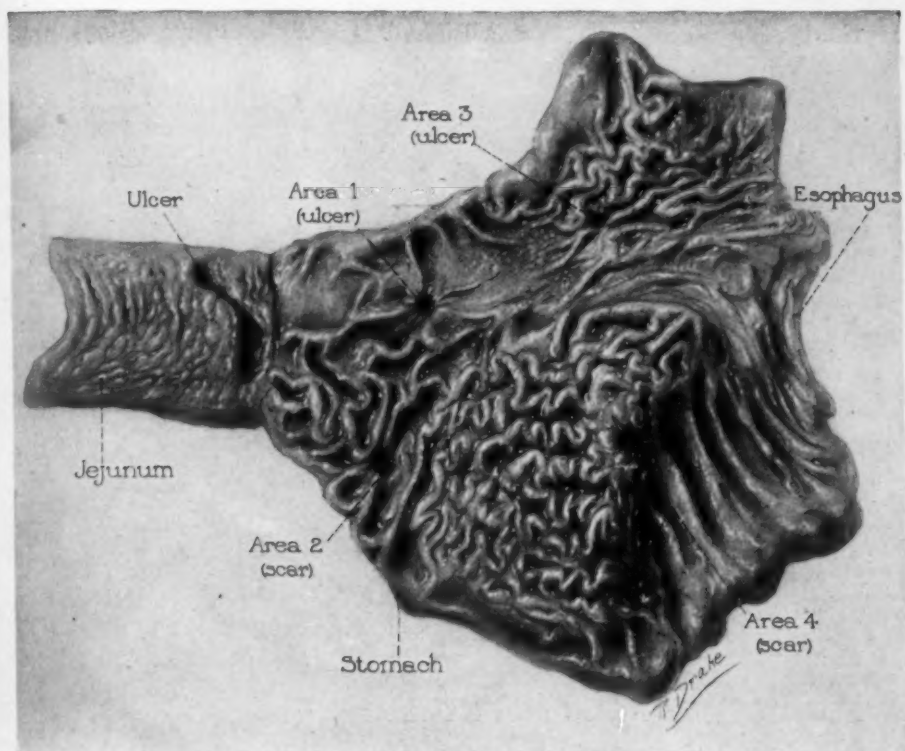


FIG. 2.—Drawing of stomach and jejunum showing typical sites of all lesions described in the experiments. Stomach one month after final operation in Group 4. Typical ulcer, chronic type, at area 1, on lesser curvature. Smaller ulcer at area 3. Areas 2 and 4 on greater curvature healed.

marked shrinkage in the size of the denuded area, sometimes leaving it only a half or a third the original size.

The areas on the lesser curvature and near the pylorus, judging by the relative sizes of the lesions at various intervals, seemed to heal a trifle more slowly than those in the fundic region and on the greater curvature. All, however, were entirely healed over with great rapidity, two weeks being apparently sufficient for an epithelial covering to form over the entire area denuded at operation. The only evidence of the original lesions was a very faintly outlined mucosal puckering and scarring more closely attached to the deeper layers of the gastric wall than the surrounding mucosa. Persistent and careful search was often necessary to find these tiny scarred areas.

In the animals in which both mucosa and muscularis were excised, the healing seemed to take place with almost as great ease and rapidity as when

only the mucosa had been excised, even when the underlying tissue had been so thoroughly excised that only the sheerest layer of serosa was left to form the base of the lesion. Microscopically, relatively small gaps were found in the muscularis at these points, showing that the muscular contraction, reducing the size of the original injury, must have played an important part in the healing process. Lesions made in the duodenum seemed to heal as readily as those made in the stomach.

The healing process, when studied microscopically in all the lesions, was found to conform closely to that described by Mann and others.

Group 2.—In this group (surgical duodenal drainage) there were twenty consecutive experiments. In all, twenty animals, an ulcer or ulcers appeared in the jejunum from 0.5 to 2 cm. distal to the line of anastomosis with the

stomach. The earliest ulcer was one discovered fourteen days after operation. The last animal in the series died from a large perforating ulcer of the jejunum four months after operation. The presence of ulcer was always determined by direct inspection at exploratory laparotomy or at necropsy. Gastric ulcers were never found in these or any other experiments in which surgical duodenal drainage

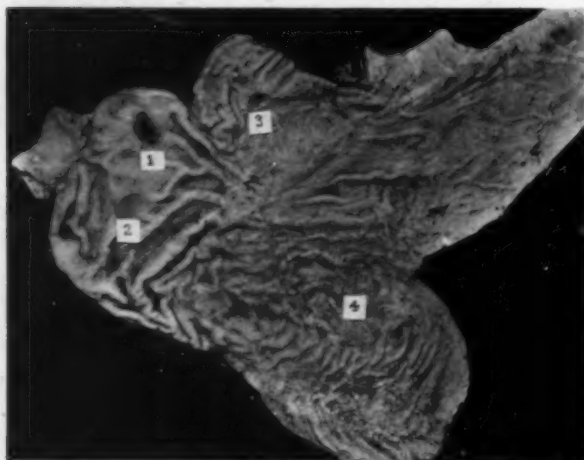


FIG. 3.—Stomach of dog in Group 3 twenty-six days after operation. Chronic-looking ulcer at area 1 perforated, causing general peritonitis and death. Small ulcer at area 3. Areas 2 and 4 healed.

alone was induced. The ulcers obtained in 100 per cent. of experiments in this group were characteristically subacute or chronic in type; since they conformed precisely to those described by Mann and Williamson, I shall not discuss them further at this time.

Group 3.—In this group (excision of gastric mucosa and surgical duodenal drainage at the same operation) there were twenty-eight consecutive experiments. Because of postmortem changes and other extraneous circumstances which marred some of the specimens, eight experiments were excluded from the series; in the other twenty, data were complete and satisfactory.

In this group the earliest observation on the stomach was four days and the latest ninety-five days after operation. In every experiment the stomach showed delay in healing (Fig. 2). Eighteen of the experiments were of more than one week's duration; in 50 per cent. of these there were very definite ulcers of the lesser curvature of the stomach that grossly and microscopically presented the appearance of subacute or chronic peptic ulcers (Figs. 3 and 4).

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Delay in healing was very much more marked on the lesser curvature than on the greater. In the same stomach there were ulcers on the lesser curvature and healing or healed areas on the greater curvature (Fig. 5). All the ulcers were found on the lesser curvature except in two experiments in which, besides the ulcer on the lesser curvature, ulcer was found on the greater curvature in the pyloric region. In general, healing of the pyloric region, even on the greater curvature, seemed to be relatively slower than healing of the fundic region of the stomach. The suture line in the anterior

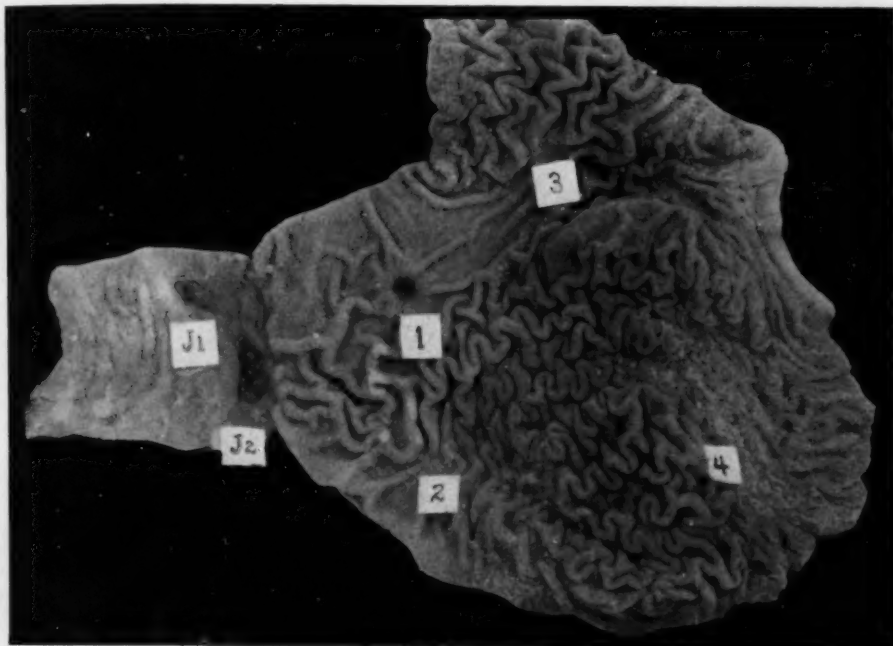


FIG. 4.—Stomach of dog in Group 4 one month after final operation. Typical ulcer chronic type, at area 1 on lesser curvature. Smaller ulcer at area 3. Areas 2 and 4 on greater curvature healed.

wall of the stomach, though slightly retarded in healing, always healed satisfactorily, the rate of healing being about the same as that for lesions in the fundic region.

Of all the areas in the stomach investigated, the lesions in the fundus on the greater curvature showed the greatest tendency to heal normally and rapidly, although they healed more slowly than similar lesions made in Group 1 in which surgical duodenal drainage was not instituted (Fig. 6).

The ulcers found in this group showed the characteristics of subacute and chronic ulcer already outlined. One had even perforated, and caused the death of the animal by acute diffuse peritonitis. Others were found on section to have perforated all layers of the stomach and were prevented from entering the general peritoneal cavity only by adhesions with the omentum or other organs.

The oldest of the ulcers was one found thirty-five days after operation,

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the death of the animal being due to perforation of the ulcer that had formed in the jejunum. This was the cause of death of most of the animals and was the reason why more long-time experiments were not available in this group.

Group 4.—In this group (surgical duodenal drainage followed in two weeks by excision of gastric mucosa) which is essentially the same as Group 3, there were twenty consecutive experiments, in all of which the data were complete and satisfactory. The earliest observation on the stomach was two days and the latest ninety days after the final operation. In every experi-

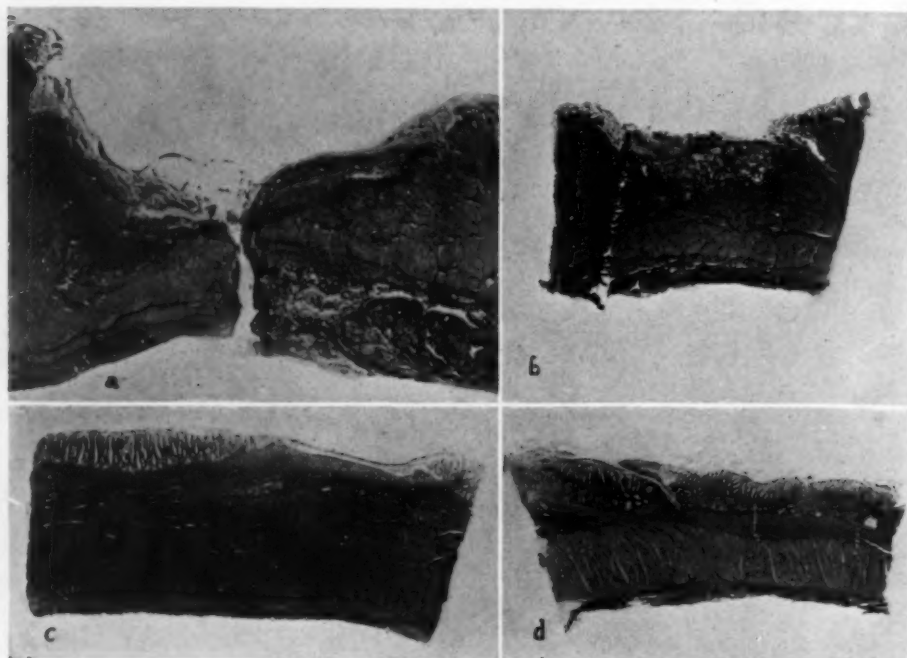


FIG. 5.—(a) Area 1, perforated ulcer, chronic type, on lesser curvature; (b) area 3, small ulcer, chronic type on lesser curvature, and (c and d) areas 2 and 4 on greater curvature, both with a complete mucosal covering, consisting of almost normal mucosa in area 4, but only a single layer of cells in area 2. Twenty-six days after operation, Group 3, (x 8).

ment the stomach showed delay in healing. Sixteen of the experiments lasted more than one week; in 62 per cent. of these there were very definite ulcers of the lesser curvature of the stomach that grossly and microscopically presented the appearance of subacute or chronic peptic ulcers (Fig. 4).

The same characteristics of delayed healing as those noted in Group 3 were present in this group and the ulcers were equally characteristic of the chronic peptic ulcer. The oldest of the ulcers in this group was one found when the animal was killed under anaesthesia two months after the final operation.

DISCUSSION

The results of the experiments in Group 1 verify those of many other investigators who have all found that acute experimental lesions in the normal stomach always heal with great rapidity and apparent ease.

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The results of the experiments in Group 2 are very striking in that peptic ulcers developed in 100 per cent. of experiments following surgical duodenal drainage after the method of Mann and Williamson. The ulcers induced by this method were characteristically chronic peptic ulcers resembling grossly and microscopically those found in the stomach and duodenum of man. Their site is important in that it bears the same relation to the stomach as that borne by the chronic duodenal ulcer in man, namely, just distal to the pylorus and at a point where the contents emptying from the stomach impinge most directly upon the flexed wall of the intestine.

The results in Groups 3 and 4 are equally as striking because factors have been introduced which in some way interfere with the inherent power of the stomach to heal, factors which not only prevent healing, but which do so to the greatest degree at exactly the region where the clinician most frequently encounters gastric ulcers, namely, the lesser curvature. These factors not only prevent healing, but actually promote erosion and cause the formation of chronic looking ulcers that grossly and microscopically have the typical characteristics of subacute and chronic peptic ulcers. It is the effect of surgical duodenal drainage which introduces these factors.

The fourth group of experiments was undertaken because of certain things which had been learned from the first and second groups: (1) Acute lesions in the normal stomach healed in about two weeks; and (2) the earliest jejunal ulcer was found two weeks after surgical duodenal drainage. Therefore, the areas of mucosa in Group 4 were excised at a second operation two weeks after the institution of surgical duodenal drainage.

On the hypothesis that the same factors were probably responsible for both the jejunal ulcer and the interference with healing in the stomach, it was hoped, by the two-stage operation, to expose the acute lesions in the stomach to the hypothetical causative factors at a time when the latter had reached such a potentiality as to be able to induce the formation of jejunal ulcers in almost 100 per cent. of cases. It was thought that by this method the conditions for the formation of chronic lesions of the stomach would be

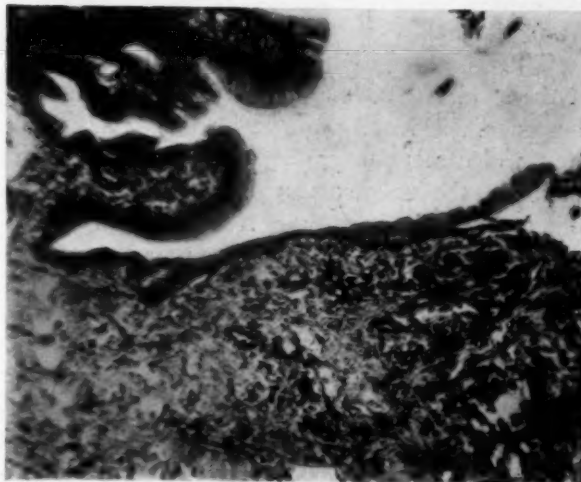


FIG. 6.—Group 1, area 1, normal healing four days after operation, showing the growing edge of mucosa consisting of a single layer of epithelial cells (x 150).

at their optimum. The results were satisfactory and showed a slight increase in the incidence of unhealed, chronic lesions.

An extremely important and significant fact, shown very well by the photographs and photomicrographs, is that in the same stomach there were two types of lesion. One was the definite chronic type of peptic ulcer on the lesser curvature; the other was the healing or completely healed lesion on the greater curvature. This is important in evaluating possible nutritional factors in relation to the non-healing on the lesser curvature. It may be said to exclude largely the animal's lowered state of nutrition as the cause of non-healing and rather suggests that the lowered nutrition may be due, at least in part, to the peptic ulcer. Such a relationship often obtains in clinical peptic ulcer.

There is an anatomic difference between the lesser and greater curvatures of the stomach that may be of some importance. On the greater curvature the mucosa is loosely attached and is readily thrown into many folds and rugæ which serve to protect a lesion of the stomach in this region mechanically. On the lesser curvature the mucosa is more closely attached and cannot so readily throw itself into folds for protection.

Moreover, the lesser curvature represents the line from which the stomach is suspended, this line being relatively fixed by the cesophagus and the gastro-hepatic omentum and ligaments. The greater curvature, on the other hand, is relatively freely movable. The tension on the lesser curvature from the suspension of the stomach might conceivably interfere slightly with the blood supply. There is another and probably more real effect produced by its anatomic position. Mapping out the lines of force according to physical principles in the contracting stomach shows that they tend to converge largely at the pylorus and along the lesser curvature. This means that the greatest amount of friction and trauma will be administered to the stomach by its emptying contents in these regions.

In the normal gastro-intestinal tract there is a relative balance maintained between the alkali of the duodenum and the acid of the stomach. At the height of gastric digestion the amount of acid in the stomach will vary, depending on many factors, such as kind and amount of food, and it is possible that the acid may be relatively high. Later in the digestive period when the gastric contents are expelled from the stomach, whatever of free acid there may be present is neutralized in the duodenum.

Surgical duodenal drainage, shunting the alkali in the duodenum to the ileum and precluding the possibility of regurgitation of alkali as far as the region of the pylorus, causes an acid-alkali imbalance in the stomach and intestine into which it empties by the practically complete removal of alkali from the region.

Surgical duodenal drainage then, with its resultant acid-alkali imbalance, not only causes the spontaneous formation of ulcers that are similar to clinical duodenal ulcers in site, structure, and other characteristics, but also interferes with the inherent healing power of the stomach and often causes acute lesions

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to develop into chronic lesions which are similar to clinical gastric ulcers in site, structure and other characteristics.

Mann attributes the situation and chronicity of the jejunal ulcers following surgical duodenal drainage to a combination of two factors: One is chemical, the destructive action of free, unneutralized acid on cells; the other is mechanical, the ease with which young growing cells can be swept away and so prevented from repairing an ulcer.

The same explanation very probably holds true for the delayed healing and non-healing in the stomach. This disturbed function is especially marked on the lesser curvature, the area of the stomach that is physiologically most subject to mechanical forces of friction and irritation in emptying the gastric contents. Since the duodenal secretions have been shunted into the ileum no regurgitation of alkali into the stomach can take place and its interior is bathed continuously in a free and unneutralized acid medium.

SUMMARY

The literature on experimental peptic ulcer and the theories of the cause of ulcer have been reviewed. The characteristics of acute and chronic ulcer with some of the means that have been used to produce them experimentally have been briefly considered and the healing process, as studied grossly and microscopically, has been outlined.

A series of experiments performed by the author has been described in four groups. In the first the inherent power of the normal stomach to heal was verified. In the second, out of a series of twenty experiments in which the operation for surgical duodenal drainage was performed after the method of Mann and Williamson, jejunal ulcers of subacute and chronic types were produced in 100 per cent. of the experiments.

In the third group, out of a series of twenty experiments in which small areas of gastric mucosa were excised and surgical duodenal drainage instituted at the same time, all areas showed delay in healing in 100 per cent. of the experiments. In 50 per cent. of all except the brief experiments, gastric ulcers of subacute and chronic type were produced on the lesser curvature while similar areas on the greater curvature healed.

In the fourth group, out of a series of twenty experiments in which surgical duodenal drainage was instituted and followed two weeks later by the excision of small areas of gastric mucosa, all areas showed delay in healing in 100 per cent. of the experiments. In 62.5 per cent. of the more prolonged experiments gastric ulcers of subacute and chronic type were produced on the lesser curvature while similar areas on the greater curvature healed.

An analysis of the conditions present and the factors operating emphasized the importance of the chemical and mechanical factors in the etiology of chronic peptic ulcer.

II. A RÖNTGENOLOGIC STUDY OF EXPERIMENTAL CHRONIC ULCER

THIS study was made to add to the data already collected on other phases of experimental, chronic, peptic ulcer. The method of surgical duodenal drainage first reported by Mann and Williamson induces chronic peptic ulcers of the duodenum and jejunum that are grossly and microscopically almost indistinguishable from the chronic peptic ulcer encountered clinically. Such lesions occur in more than 90 per cent. of experiments and lend themselves readily to röntgenologic study. In these experiments the presence of ulcers and their effect on gastric motility were studied fluoroscopically and photographically with the Röntgen-ray.

Nothing could be found in the literature on the röntgenology of experimental ulcer. A vast amount of work has been done on the experimental production of ulcer and a few observers have succeeded in producing lesions that resemble chronic ulcer. I reviewed this work in a previous paper and described a method of producing chronic ulcers in the stomach. Further review will not be made here.

Much has been written also on the value of the Röntgen-ray in the diagnosis of clinical peptic ulcer. Clinical gastro-intestinal röntgenology has, however, no direct bearing on this work other than in technical details, and no attempt will be made to review it here. The röntgenologic technic used in these experiments is essentially that described by Carman and is used in the gastro-intestinal examinations at the Mayo Clinic.

METHOD OF EXPERIMENTATION

Medium-sized dogs weighing from 10 to 15 kg., selected for their good nature and adaptability to handling, were used throughout the experiments. Operations were carried out under ether anaesthesia and aseptic technic. No rubber-covered or other intestinal clamps and no unabsorbable sutures were employed in any of the operative procedures. All Röntgen-ray examinations and all operations were carried out by me.

After each animal had received opaque meals, I examined it on several occasions under the fluoroscope and by means of röntgenograms to impress a normal gastro-intestinal picture on my mind, and to determine that each animal conformed to this normal picture. Examinations were always made with the animal in various positions, but it was found most satisfactory to take the röntgenogram with the animal in the prone position, belly resting on the plate and the Röntgen-ray tube above the animal's back and about eighteen inches from the plate.

In determining the most satisfactory opaque meal for routine use, three were tried. The first, called the barium meal, consisted of equal parts by weight of barium sulphate powder, gum acacia solution, and condensed milk. The gum acacia solution was made from lump gum acacia dissolved in water to form a syrupy solution of about the consistency of ordinary commercial corn syrup. The meal was administered to the dogs in the dosage of 15 gm. for each kilogram of body weight. This meal has long been used as a

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standard for Röntgen-ray examinations of the gastro-intestinal tract in this laboratory. The second, the barium-meat meal, consisted of one-third by weight of cooked ground meat and two-thirds of barium meal. The amount administered was 15 gm. for each kilogram of body weight. The third, the barium-sugar meal, consisted of equal parts by weight of cane sugar and barium meal administered in amounts equal to 15 gm. for each kilogram of body weight.

Food was withheld for twenty-four hours preceding the examination and the dogs usually ate the opaque meals with relish. The fasting period was continued through the time of the examination. Following the ingestion of the meal the animals were examined at once under the fluoroscope and röntgenograms were taken within ten minutes. The size, shape, position and emptying characteristics of the stomach and duodenum were studied carefully. Other examinations, both fluoroscopic and röntgenographic, were made at intervals of three, five, and seven hours following the ingestion of the opaque meal. Between examinations animals were returned to their cages. The dogs soon became accus-

tomed to the procedures and were handled with great ease. After several examinations of the gastro-intestinal tract of the normal animal had demonstrated that the animal conformed to the normal picture, operation was performed in order to produce peptic ulcer.

The operative procedure of surgical duodenal drainage is as follows: The pylorus is severed, the distal end closed, the first part of the jejunum is severed and the proximal end closed. End-to-end anastomosis is then made between the proximal end of the severed pylorus and the distal end of the severed jejunum, and the continuity of the gastro-intestinal tract thus restored. Then, to form an outlet for the closed segment of gut consisting

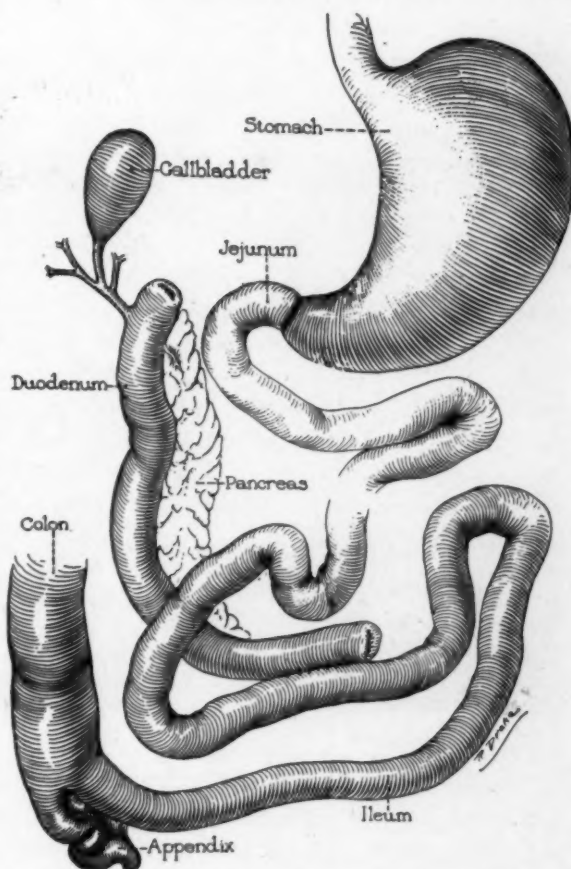


FIG. 1.—Diagram of the operative procedure of surgical duodenal drainage.

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of the duodenum and a small part of the first portion of the jejunum, a side-to-side anastomosis is made between this closed portion of jejunum and the lower ileum about 25 cm. proximal to the ileocaecal valve (Fig. 1). The result of this is to substitute the jejunum functionally and anatomically for the duodenum. The duodenum with its alkaline secretion and the alkaline bile and pancreatic juice is drained into the ileum at such a distance that regurgitation of alkali into the stomach or the gut immediately adjacent to it is precluded.

In large series of animals, in which this operation has been performed, ulcer has developed in almost 100 per cent. These ulcers tend to bleed and perforate and are grossly and microscopically almost indistinguishable from

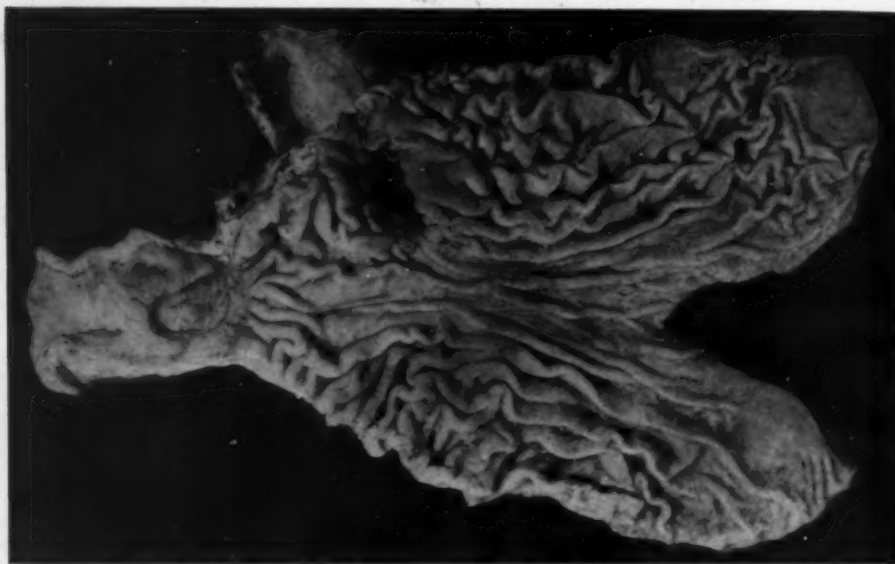


FIG. 2.—Stomach and anastomosed jejunum. Typical ulcer in jejunum following surgical duodenal drainage (Dog J-167).

the chronic peptic ulcer found clinically in the duodenum of man. The ulcer occurs in the transplanted jejunum just distal to the pylorus, usually about 1 cm. from the suture-line and at the point where the emptying acid chyme impinges on the wall of the flexed gut (Fig. 2). It bears the same relationship to the pylorus as does the usual duodenal ulcer in man. By exploratory laparotomy it has been found possible to trace the development of these ulcers from small, acute, superficial lesions to large, deep, indurated craters. Because of these characteristics this type of ulcer seemed admirably suited to röntgenologic study.

After operation the animals received the usual care and diet, with milk and syrup added in order to maintain a higher level of nutrition. Röntgenologic examinations were made at approximately weekly intervals. After the ulcer had developed, examinations were often made at more frequent intervals, and exploratory laparotomy was also performed on some of the dogs in order to compare the gross and röntgenologic findings.

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RESULTS

Thirty-six röntgenologic examinations were made in twelve normal animals. In most cases the barium meal was used, though the barium-meat and barium-sugar meals were used in several for comparison.

The findings in the normal animals demonstrated in particular that the gastro-intestinal tract of the dog could be examined röntgenologically with considerable ease and precision. The shape of the dog's stomach was found slightly different from that of man, but it was nevertheless quite constant. In other respects the stomach and duodenum conformed very closely to the röntgenographic appearance of the stomach and duodenum of man (Figs. 3a and 4a). The röntgenologic findings in this series of normal animals conformed very closely also to previous findings in large series of dogs examined at other times in this laboratory.

It was found that the barium meal passed on and left the stomach of



FIG. 3.—(a) Before operation; (b) twenty days after operation, and (c) thirty-six days after operation, showing tremendous gastric dilatation and retention (Dog I-25).

the normal animal empty in from three to four hours. The barium-meat meal passed through more slowly and with less regularity and the stomach was not entirely empty until five or six hours after the ingestion of the meal. The barium-sugar meal passed through more rapidly than the barium meal and left the stomach empty in three hours or less. Because of these findings the barium meal was adopted as the standard opaque meal, being in every way more uniform than the other two opaque meals tried.

Of the twelve animals studied as normal controls, six were studied for ulcer formation following surgical duodenal drainage. Thirty-seven röntgenologic examinations were made in these six animals after operation (Tabulation).

For the first two or three weeks following operation the röntgenologic characteristics of the stomach and intestine into which it emptied were almost indistinguishable from those in the normal animal (Fig. 4e). The only difference was that following operation the pylorus did not function as efficiently as it did in the intact animal. The opaque meal tended to dribble somewhat through the pylorus even when the stomach was not in the contracting phase. The stomach, however, seemed to contract with the same rhythm and in the same manner whether or not operation had been performed.

About the third or fourth week after operation, a change was noticeable

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Synopsis of Protocols of Six Animals Examined for Ulcer Formation.

Dog	Date of operation	Number of examinations after operations	Röntgenologic examination		Exploratory laparotomy		Date of death	Necropsy, findings	Remarks.
			Date	Findings	Date	Findings			
H 812	4- 8-25	7	5- 7-25 5-13-25	Suspicious of ulcer. Definite ulcer			7-13-25	Large, typical chronic ulcer that had caused death by perforation	Typical chronic ulcer diagnosed by Röntgen-ray and verified at necropsy.
I 24	4-23-25	7	5-27-25 8- 7-25	Suspicious of ulcer. More suspicious			8-18-25	Subacute ulcer that had caused death by perforation	Subacute ulcer suspected by Röntgen-ray and verified at necropsy.
I 25	4-23-25	2	5-29-25	Stomach tremendously dilated; ulcer surmised			6-12-25	Subacute ulcer that had caused death by perforation	Subacute ulcer suspected by Röntgen-ray and verified at necropsy.
J 99	4-26-26	9			6-17-26	No ulcer present and entire gastro-intestinal tract apparently normal	7- 1-26	Ulcer that had perforated in the acute developing stage and caused death	Acute ulcer. Röntgen-ray and exploratory laparotomy failed to find the ulcer which no doubt developed only a few days before death.
J 118	4-26-26	9	5-26-26 6- 2-26 6-28-26	Definite ulcer. Ulcer grown larger. Ulcer smaller and less distinct	6- 3-26 6-17-26	Large chronic ulcer. Ulcer grown larger (gastro-enterostomy performed)	7- 2-26	Perforating acute ulcer opposite the gastro-enteric stoma. Original ulcer diagnosed by Röntgen-ray had healed considerably	Typical chronic ulcer diagnosed by Röntgen-ray and verified by exploration. Partially healed as seen in Röntgen-ray, verified by necropsy.
J 167	5- 4-26	3	5-26-26	Definite ulcer	6- 3-26	Large chronic ulcer that had apparently perforated within 2 or 3 hours preceding exploration. Gastro-enterostomy performed in the hope of saving animal. Perforation closed	6- 4-26	Considerable peritonitis as found at exploration. Large perforating ulcer as repaired at exploration	Typical chronic ulcer diagnosed by Röntgen-ray and verified by exploration and necropsy.

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in the animals. The stomach did not empty quite as fast as it had during the first two weeks and there was a little tendency toward gastric stasis (Fig. 3*b*), this in spite of the fact that the actual contractions of the stomach seemed little altered. It was about this time that the outline of the intestine just distal to the pylorus began to show irregularity which in later examinations resolved itself into a definite ulcer-crater (Fig. 4*b, c* and *f*). In one animal the gastric stasis became so marked that the shadow of the stomach

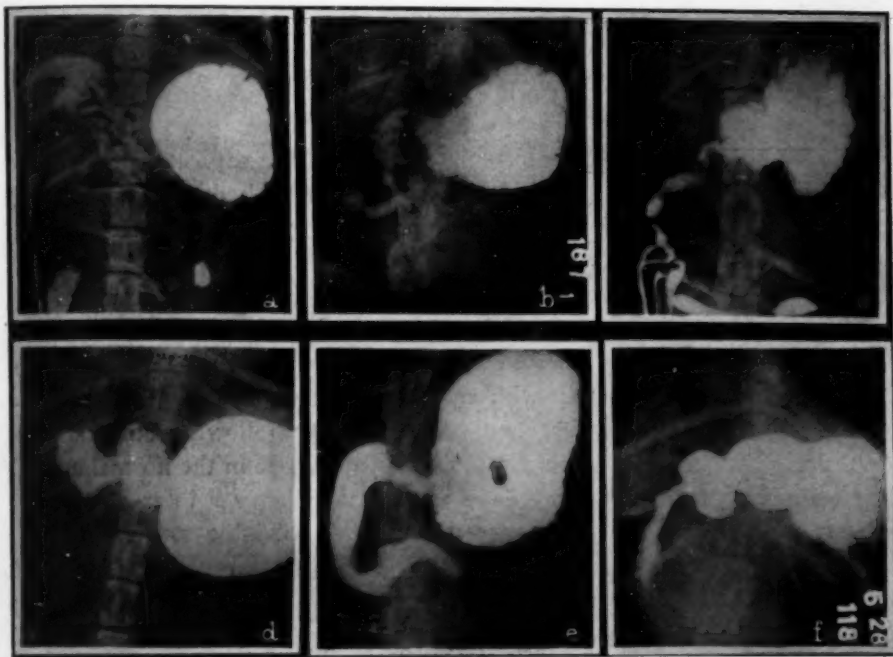


FIG. 4.—(a) Before operation; (b) twenty-two days after operation, showing ulcer-crater; (c) thirty days after operation showing enlargement of crater; (d) before operation; (e) a few days after operation showing normal tract, and (f) thirty days after operation showing ulcer-crater (Dog J-167, a, b, and c) and (Dog J-118, d, e, and f).

filled almost the entire upper abdomen and made further röntgenologic examination of little value. (Fig. 3*c*.)

In every one of the animals an ulcer appeared at the usual site of ulcer formation following surgical duodenal drainage. Of the six ulcers, three were typically chronic in type and each of them was diagnosed by the Röntgen-ray. Two others were of the subacute type and, although suspected at fluoroscopic examination, were not depicted with certainty in the röntgenograms. One was an acute ulcer that apparently formed after the last Röntgen-ray examination and just before the animal's death.

It has been found in a few experiments in a large series that the usual chronic ulcer does not appear, but instead an acute ulcer forms very rapidly and perforates within twenty-four or forty-eight hours from the time of its first appearance.

In one animal in which a large crater-shaped, indurated ulcer was demon-

strated röntgenologically and at exploration, the stomach was anastomosed to a loop of jejunum about 50 cm. distal to that containing the ulcer. A large stoma was made in order that the greater part of the gastric contents might empty through it. Following this operation, the large ulcer just distal to the pylorus became much smaller and more difficult to depict with the Röntgen-ray. At necropsy, fifteen days later, this ulcer had lost its induration and deep crater-like shape, and had healed considerably, although not as rapidly as the healing described by Mann after gastro-enterostomy and pyloric exclusion, to protect the ulcer completely from the acid chyme.

DISCUSSION

It was to be expected that the high-protein, barium-meat meal would pass through the stomach slowly and the high-carbohydrate barium-sugar meal rapidly. It is well known that the period of gastric digestion for meat is long while that for sugar is short.

The röntgenologic similarity between the gastro-intestinal tract of the dog and of man, as demonstrated in these experiments, brings experimental data on gastro-intestinal physiology and pathology in the dog into correspondingly closer relationship with clinical problems.

The characteristics of the stomach immediately following surgical duodenal drainage were almost indistinguishable from those in the normal animal. The operative procedure changed very radically whatever inter-relationship there may have been normally between the acid-containing stomach and the alkali-containing duodenum. In spite of this the motility of the stomach was essentially unchanged until after the ulcer had commenced to form. After it had formed, gastric peristalsis seemed still essentially normal, although the gastric contents did not seem to empty quite so readily. It is most probable that the intestine into which the stomach emptied was responsible for the interference with the emptying process, and that either a mechanical obstruction was offered by the ulcer or else a spasm of the intestine was caused by the ulcer. Cicatricial contraction of the suture-line was not a factor, for inspection at necropsy failed to show any narrowing of the lumen at this point.

The fact that experimental peptic ulcers were depicted röntgenologically needs little comment. Röntgenograms of the three large chronic ulcers showed unmistakable craters. In one of these the healing process following gastro-enterostomy was detected. Two other subacute ulcers were suspected fluoroscopically, but plates showing a definite crater could not be obtained. The relative shallowness of the ulcers probably accounts for this failure. An acute ulcer was never found at any Röntgen-ray examination and, even at exploration fourteen days before death, no ulcer was present. As already suggested, this ulcer is one of the type occasionally encountered that develops and perforates with extreme rapidity.

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SUMMARY

Twelve normal dogs were given opaque meals, after which röntgenologic examinations of the gastro-intestinal tract were made. Such examinations were very satisfactory and were found similar to those of human subjects. Following the study of the normal tract, six of the dogs were studied for ulcer formation following surgical duodenal drainage as described originally by Mann and Williamson. Ulcers developed in all of the six dogs. Three were typical of the chronic type with deep craters; röntgenograms of each were obtained. Two were subacute lesions, suspected at fluoroscopic examination but not definitely shown in the röntgenograms. One was an acute ulcer and apparently developed and perforated suddenly after the last Röntgen-ray examination. In one of the chronic ulcers the healing process following gastro-enterostomy was observed.

The feasibility of röntgenologic study of experimental peptic ulcer was demonstrated.

Motor changes of the gastric musculature could not be detected as etiologic factors in the production of these ulcers.

III. HEALING OF EXPERIMENTAL PEPTIC ULCER AFTER GASTRO-ENTEROSTOMY

SURGICAL duodenal drainage induces the formation of chronic types of peptic ulcer in the jejunum of dogs in more than 90 per cent. of experiments. The ulcers often bleed and perforate and, in gross and microscopic characteristics and in their relation to the pylorus, are practically indistinguishable from peptic ulcers of the duodenum found in man. Such ulcers seem admirably suited for studying the effects of gastro-enterostomy, a treatment used so frequently in clinical cases of peptic ulcer.

LITERATURE

Mann and Williamson devised the operation for surgical duodenal drainage. In their first experiments they transplanted the common bile duct and pancreatic ducts into the ileum, thereby greatly decreasing the alkalinity of the duodenum. Following this procedure they found typical chronic peptic ulcers in the duodenum just distal to the pylorus in ten of thirty-one experiments. In later experiments they modified the procedure by draining the entire duodenum into the ileum, and anastomosing the jejunum to the pylorus so that anatomically the jejunum took the place of the duodenum. They found typical chronic peptic ulcers in the jejunum just distal to the pylorus in more than 90 per cent. of such experiments.

In previous pages I have reviewed the literature on the production and the healing of peptic ulcers in experimental animals, described the operation for surgical duodenal drainage, reported a method of producing typical chronic ulcer on the lesser curvature of the stomach in dogs, and presented some observations on the healing process in the gastric mucosa of dogs. Mann has studied in detail the healing process in peptic ulcer of the jejunum of the dog. Caylor and Kennedy have described the healing process in peptic

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ulcer found in man. In a röntgenologic study of experimental ulcer I reported an experiment in which following simple gastro-enterostomy a very large chronic type of peptic ulcer showed definite evidence of healing both röntgenologically and at necropsy.

The literature with reference to the clinical use of gastro-enterostomy is too voluminous for consideration here. It is sufficient to say that gastro-enterostomy is one of the most commonly employed of surgical measures in treating clinical peptic ulcer.

METHODS OF EXPERIMENTATION

Normal healthy dogs were used in all experiments and for all operative procedures ether anæsthesia and aseptic technic were employed. No rubber-covered or other intestinal clamps and no unabsorbable sutures were used in any of the operations. After the operation for surgical duodenal drainage into the ileum the dogs received the usual care of normal animals, with milk and syrup added to their diet in order to maintain a better state of nutrition. They seemed to stand the operation well and usually remained in good condition until the ulcer of the jejunum, developing at the usual site of ulceration following surgical duodenal drainage, reached a considerable degree of chronicity. In large numbers of dogs following this operation, it has been found that the ulcer usually begins to form from two to six weeks after operation and steadily increases in size and chronicity until perforation of the ulcer and death of the dog occur several weeks or months later. The base of such an ulcer frequently adheres to the omentum or other adjacent tissues so that often the ulcer reaches a considerable depth and degree of induration before perforation into the general peritoneal cavity takes place.

Exploratory laparotomy was performed in this series of experiments in from three to nine weeks following surgical duodenal drainage. The ulcer of the jejunum was in every case carefully examined and its size, shape, depth, and degree of induration recorded.

After this a loop of jejunum about 20 to 40 cm. distal to that containing the ulcer was brought into place and a gastro-enteric stoma made in the usual manner in the anterior wall of the stomach about 4 cm. proximal to the pylorus. An isoperistaltic loop was used and the stoma made large enough for the greater part of the gastric contents to empty through it.

Necropsy was performed on each dog at various intervals after gastro-enterostomy. The ulcer of the jejunum was carefully examined and its size, shape, depth, and degree of induration recorded and compared with the characteristics of the ulcer previous to gastro-enterostomy.

RESULTS

The operation for surgical duodenal drainage into the ileum was performed in nine healthy, normal dogs. Exploratory laparotomy was performed at various intervals from twenty to sixty-five days afterwards. A peptic ulcer was found in the jejunum of every dog (Fig. 1). At the same laparotomy gastro-enterostomy was performed in each dog.

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The intervals between gastro-enterostomy and necropsy varied from four to sixteen days. In every case the ulcers showed unmistakable evidence of healing (Fig. 2). In two experiments small but typical chronic ulcers had healed entirely in ten and fifteen days, respectively, after gastro-enterostomy. In another experiment a typical indurated chronic ulcer, measuring at exploration 1 cm. in diameter and 0.5 cm. in depth, had healed almost completely in a period of sixteen days (Fig. 3).

The rate of healing of the ulcers in these experiments after gastro-



FIG. 1.—Typical ulcer of jejunum following surgical duodenal drainage. Site of gastro-enterostomy performed a few hours previously in the stomach also shown.

enterostomy was in direct proportion to the size and degree of chronicity of the ulcer. As might be expected in the limited time allowed in the experiments, healing was more complete in small than in large ulcers (Tabulation).

The ulcers were also studied microscopically. All those studied showed evidence of healing. The inflammatory reaction and the induration of the ulcer seemed to subside first. Granulation tissue replaced the dirty, necrotic base and margins and gradually filled in the crater of the ulcer (Figs. 4 and 5). At the same time epithelial cells grew out in a single layer and covered the granulation tissue. The process continued until, in the completely healed lesions previously mentioned, the entire area of the former ulcer was covered with epithelium which formed atypical glands and finally simulated in many respects the normal mucosa of the intestine.

Healing of these ulcers, however, was not as rapid and clean and orderly as that described by Mann who studied the healing of peptic ulcer of the jejunum after completely occluding the pylorus and draining all the gastric

contents through a gastro-enteric stoma. By his method he completely protected the ulcer from all contact with acid chyme and thereby established ideal conditions for the healing process.

Besides the healing ulcers found at necropsy, new developing ulcers were usually found in the efferent loop of jejunum just opposite the gastro-enteric stoma. These ulcers were found always at the point in the efferent loop against which the emptying acid chyme impinged most directly.

DISCUSSION

Typical chronic peptic ulcers were found in 100 per cent. of these experiments with surgical duodenal drainage. The ulcers formed at the usual site,



FIG. 2.—Healing ulcer. Arrow indicates ulcer, pointer indicates gastro-enteric stoma indistinctly seen through incision in the stomach. Seven days after gastro-enterostomy.

just distal to the pylorus and at the point where the acid chyme in emptying from the stomach impinged most directly against the wall of the intestine. Mann likens the pylorus to a nozzle, through which the gastric contents are emptied in a jet-like stream.

Under normal conditions the stomach empties its acid chyme into a portion of intestine which contains a highly alkaline secretion capable of neutralizing considerable amounts of acid. Under the conditions resulting from surgical duodenal drainage this is no longer the case. A highly acid chyme is forcibly ejected

through the pyloric nozzle by the impulse of gastric contractions and impinges against the wall of a portion of intestine which contains little or no alkali.

The relative constancy in occurrence and site of the ulcers following surgical duodenal drainage seems partly, if not completely, explained by these factors: the absence of alkali to neutralize the acid ejection from the stomach and the manner in which the acid chyme is repeatedly ejected against a relatively circumscribed area of the wall of the intestine.

In these experiments 100 per cent. of typical chronic peptic ulcers showed definite signs of healing after gastro-enterostomy, and in two experiments healing was complete. The gastro-enteric stoma was designed to empty the greater part of the gastric contents and to decrease the amount and the force of acid ejections from the pylorus. The result was that the original ulcer of the jejunum began to heal, but at the same time a new ulcer began to form

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Synopsis of the Protocols of the Nine Experiments with Healing Ulcer.

Experiment	Surgical duodenal drainage. Date, 1926	Exploration and gastro-enterostomy			Necropsy		
		Date, 1926	Interval, days	Findings and Remarks	Date, 1926	Interval, days	Findings and Remarks
1	4-26	6-3 6-17	38 52	Chronic ulcer 1 cm. in diameter. (No gastro-enterostomy) Chronic ulcer 2 by 1.5 cm., 1 cm. in depth	7-2	15	Marked healing. Induration has subsided. Ulcer only 1 by 1.8 cm. in diameter and 0.3 cm. in depth.
2	6-25	7-15	20	Two subacute ulcers, each 0.5 cm. in diameter and about 0.4 cm. in depth	7-30	15	Both ulcers entirely healed. Difficult to find scars.
3	6-25	7-15	20	Two subacute ulcers, one 0.3 cm. in diameter and 0.3 cm. in depth, the other 0.6 cm. in diameter and 0.2 cm. in depth	7-24	9	Both ulcers entirely healed. Difficult to find scars.
4	7-5	9-8	65	Chronic ulcer 1 cm. in diameter and 0.5 cm. in depth	9-18	10	Marked healing. Induration has subsided. Ulcer now 0.6 cm. in diameter and 0.1 cm. in depth.
5	7-19	9-8	51	Subacute ulcer 1.5 cm. in diameter and 0.2 cm. in depth	9-15	7	Definite healing. Induration has subsided. Size unchanged.
6	7-19	9-9	52	Chronic ulcer 1.5 cm. in diameter and 0.7 cm. in depth	9-19	10	Definite healing. Induration has subsided. Diameter of ulcer unchanged, depth now 0.2 cm.
7	7-19	9-9	52	Chronic ulcer 1 cm. in diameter and 0.5 cm. in depth	9-25	16	Marked healing, almost complete. Superficial scar-like area 0.4 cm. in diameter remains.
8	7-22	9-10	50	Chronic ulcer 1.5 cm. in diameter and 0.5 cm. in depth	9-14	4	Definite healing. Induration has subsided. Diameter of ulcer unchanged, depth now 0.2 cm.
9	7-29	9-13	46	Chronic ulcer 1.5 cm. in diameter and 0.7 cm. in depth	9-20	7	Marked healing. Induration has subsided. Ulcer now 0.7 by 0.6 cm. and 0.1 cm. in depth.

in the loop leading from the gastro-enteric stoma. The new ulcer formed opposite the stoma at the point where the acid chyme emptying from the stomach impinged most directly and forcibly against the wall of the intestine.

A gastro-enteric stoma situated, in these experiments, only a short distance from the site of the original ulcer could not appreciably alter the concentration of acid present in the region of the ulcer by any process of neutralization. The alkaline secretions were drained too far distally in the intestinal tract for that possibility to be entertained. Gastro-enterostomy apparently



FIG. 3.—Healing ulcer. Arrow indicates ulcer which has healed almost entirely. Large newlyforming ulcer is just to the right of the gastro-enteric stoma and in the efferent loop. Sixteen days after gastro-enterostomy.

introduced merely an accessory outlet for the acid chyme of the stomach, thereby decreasing the amount and the force of the ejections from the pylorus and so protecting the original ulcer from the degree of trauma to which it had been subjected in the developing stages. This explanation seems to be substantiated by the development of the new ulcer opposite the stoma

in the efferent loop of the anastomosis. The stoma was designed to bear the brunt of the burden of emptying the stomach, and therefore the same factors that induced the original ulceration were made to operate at the point where the new ulcer developed.

In these experiments gastro-enterostomy after surgical duodenal drainage could not introduce alkali into the ulcer-bearing area, but promoted healing of chronic ulcers apparently by distributing the forces of gastric ejections over larger areas. Gastro-enterostomy as employed in clinical cases of peptic ulcer may not only distribute the force of gastric ejections, but also may introduce alkali into the ulcer-bearing area by way of the afferent loop.

From the data of experiments the presence of adequate amounts of alkali in the ulcer-bearing area, and the proper distribution of the force of ejections from the emptying stomach, are suggested as having an important bearing on the etiology and treatment of chronic peptic ulcer.

SUMMARY

Some previous work on the production and the healing of peptic ulcers in experimental animals and in man was briefly reviewed. Experiments were performed in which, following the operation for surgical duodenal drainage in nine dogs, typical chronic peptic ulcers of the jejunum developed in 100

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per cent. of the cases. Ulcers were carefully measured at exploratory laparotomy. Gastro-enterostomy designed to empty the greater part of the gastric

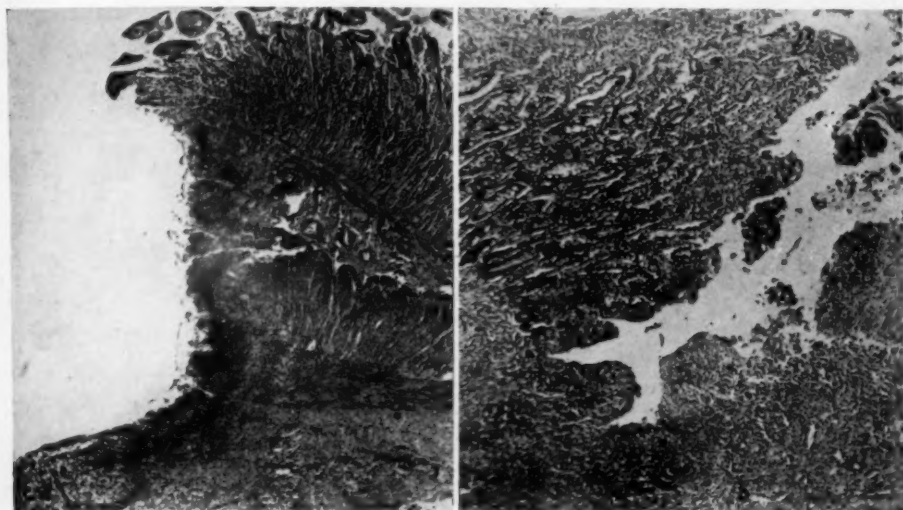


FIG. 4.—(a) Typical margin of the usual chronic ulcer after surgical duodenal drainage (X 25). Note necrotic and infiltrated edges and wedge-shaped submucosa. (b) Margin of typical healing ulcer four days after gastro-enterostomy (X 60). Note granulation tissue filling in the crater and mucosa growing out to cover it.

contents through the new stoma was then performed in all animals. At necropsy, performed at various intervals after gastro-enterostomy, evidence of healing was present in 100 per cent. of the ulcers. In two experiments the ulcers healed entirely and in one experiment a deep chronic ulcer, 1 cm. in diameter and 0.5 cm. in depth, healed almost completely in sixteen days following gastro-enterostomy. The rate of healing in the ulcers was directly proportional to the size and chronicity of the ulcer and to the length of time after gastro-enterostomy. Coincident with the healing of the original ulcers new ulcers formed in the efferent loops of the gastro-enteric anastomosis. The acid-alkali imbalance following surgical duodenal drainage, and the force with which the contents emptying

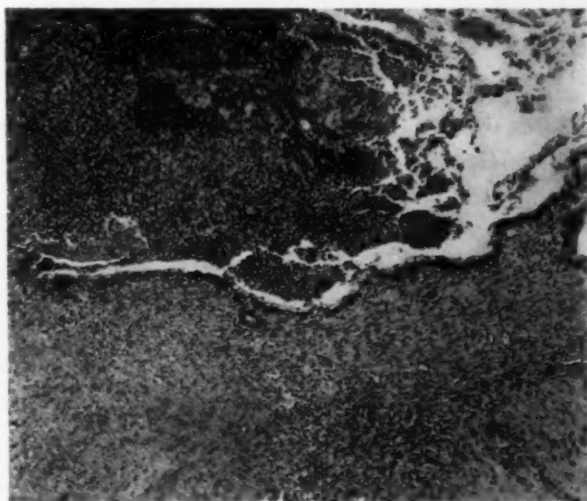


FIG. 5.—Margin of typical healing ulcer seven days after gastro-enterostomy (X 60). Note layer of epithelium extending far out over the area of granulation tissue.

from the stomach impinged directly on a relatively circumscribed area of the intestinal wall, were suggested as having an important bearing on the formation of chronic ulcers after surgical duodenal drainage. The healing of these ulcers, with the coincidental formation of new ulcers in the efferent loop, was brought about by gastro-enterostomy and the consequent alteration in the factors that caused ulceration. The probable bearing of the same factors on the etiology and treatment of clinical chronic peptic ulcer was mentioned.

BIBLIOGRAPHY—PART I

- ¹ Baillie, M.: Quoted by Bolton.
- ² Bauhin, J.: Quoted by Lebert.
- ³ Bedarida, N. V.: *Produzione sperimentale di ulcera gastrica*. Arch. ital. di chir., Bologna, 1924, vol. ix, pp. 109-147. (Abst. Jour. Am. Med. Assn., 1924, vol. lxxxii, p. 1738.)
- ⁴ Bolton, C.: *Ulcer of the Stomach*. London, Arnold, 1913, 396 pp.
- ⁵ Brinton, William: *Diseases of the Stomach*. 2nd Ed., London, Churchill, 1864, vol. cxxiv, p. 133.
- ⁶ Butsch, J. L.: *Ulcers of the Gastro-intestinal Tract with Special Reference to Gastro-jejunal Ulcers*. Papers from The Mayo Foundation and Medical School of the University of Minnesota, 1915-1920, vol. i, pp. 57-84.
- ⁷ Caylor, H. D.: *The Healing of the Gastric Ulcer in Man*. ANNALS OF SURGERY, 1926, vol. lxxxiii, pp. 350-356.
- ⁸ Celsus: Quoted by Bolton.
- ⁹ Cohnheim, J.: *Lectures on General Pathology*, London, New Sydenham Society, 1890, vol. iii, p. 879.
- ¹⁰ Crämer, Friedrich: *Ueber die Ablösung der Magenschleimhaut durch die Sondierung und ihre Folgen*. München. med. Wchnschr., 1891, vol. xxxviii, pp. 903-904.
- ¹¹ Cruveilhier, Jean: *Anat. pathologique du corps humain*. Paris, J. B. Bailliere, 1829-1842, 2 vs. Quoted by Bolton.
- ¹² Dott, N. M., and Lim, R. K. S.: *Experimental Jejunal Ulcer*. Quarterly Jour. of Exper. Physiol., 1923, supplement (Proc. xi int. Physiol. Cong.), Edinburgh, pp. 109-110.
- ¹³ Dragstedt, L. R., and Vaughan, A. M.: *Gastric Ulcer Studies*. Arch. Surg., 1924, vol. viii, pp. 791-810.
- ¹⁴ Durante, L.: *The Trophic Element in the Origin of Gastric Ulcer*. Surg., Gynec. and Obst., 1916, vol. xxii, pp. 399-406.
- ¹⁵ Exalto, J.: *Ulcus jejuni nach Gastroenterostomie*. Mitt. a. d. Grenzgeb. d. Med. u. Chir., 1911, vol. xxiii, pp. 13-41.
- ¹⁶ Fenwick, S., and Fenwick, W. S.: *Ulcer of the Stomach and Duodenum and its Consequences*. London, J. and A. Churchill, 1900, pp. 80, 82, 83, 93.
- ¹⁷ Friedman, J. C., and Hamberger, W. W.: *Experimental Chronic Gastric Ulcer*. Jour. Am. Med. Assn., 1914, vol. lxiii, pp. 380-384.
- ¹⁸ Greggio, Ettore: *Des ulcères gastro-duodénaux*. Arch. de méd. exper. et d'anat. path., 1916-1917, vol. xxvii, pp. 533-590.
- ¹⁹ Griffini, L., and Vassale, G.: *Ueber die Reproduktion der Magenschleimhaut*. Beitr. z. path. Anat. u. z. allg. Path., 1888, vol. iii, pp. 425-448.
- ²⁰ Hoffman, Albert: *Experimental Gastric and Duodenal Inflammation and Ulcer*. Amer. Jour. Med. Sc., 1925, vol. clxx, pp. 212-219.
- ²¹ Ivy, A. C.: *Studies on Gastric and Duodenal Ulcer*. Jour. Am. Med. Assn., 1920, vol. lxxv, pp. 1540-1542.

OBSERVATIONS ON PEPTIC ULCER

- ²⁰ Kehrer, J. K. W.: Ueber die Ursache des runden Magengeschwürs. *Mitt. a. d. Grenzgeb. d. Med. u. Chir.*, 1914, vol. xxvii, pp. 679-693.
- ²¹ Kennedy, R. L. J.: Etiology and Healing Process of Duodenal Ulcer in Melena Neonatorum. *Am. Jour. Dis. Child.*, 1926, vol. xxxi, pp. 631-638.
- ²² Lebert, H.: Die Krankheiten des Magens. Tübingen, H. Laupp, 1878, p. 180.
- ²³ Leube, W. O.: Bemerkungen über die Ablösung der Magenschleimhaut durch die Magensonde und ihre Folgen. *Deutsch. Arch. f. klin. Med.*, 1876, vol. xviii, pp. 496-505.
- ²⁴ Mann, F. C.: Production and Healing of Peptic Ulcer; an Experimental Study. *Minn. Med.*, 1925, vol. viii, pp. 638-640.
- ²⁵ Mann, F. C.: The Chemical and Mechanical Factors in Experimentally Produced Peptic Ulcer. *Surg. Clin. N. Amer.*, 1925, vol. v, pp. 753-775.
- ²⁶ Mann, F. C., and Williamson, C. S.: The Experimental Production of Peptic Ulcer. *ANNALS OF SURGERY*, 1923, vol. lxxvii, pp. 409-422.
- ²⁷ Matthes, M.: Untersuchungen über die Pathogenese des Ulcus rotundum ventriculi und über den Einfluss von Verdauungsenzym auf lebendes und todes Gewebe. *Beitr. z. path. Anat. u. z. allg. Path.*, 1893, vol. xiii, pp. 309-364.
- ²⁸ Mayo, W. J.: Ulcer of the Stomach and Duodenum with Special Reference to the End Results. *ANNALS OF SURGERY*, 1911, vol. liv, pp. 313-320.
- ²⁹ Pavy, F. W.: On Gastric Erosion. *Guy's Hosp. Reports*, 1867, 3d Series, vol. xiii, pp. 494-509.
- ³⁰ Quincke and Daettwyler: Quoted by Bolton.
- ³¹ Robertson, H. E., and Hargis, E. H.: Duodenal Ulcer: An Anatomical Study. *Med. Clin. N. Amer.*, 1925, vol. viii, pp. 1065-1092.
- ³² Rosenow, E. C.: The Causation of Gastric and Duodenal Ulcer by Streptococci. *Jour. Infect. Dis.*, 1916, vol. xix, pp. 333-384.
- ³³ Rosenow, E. C.: The Specificity of the Streptococcus of Gastro-duodenal Ulcer and Certain Factors Determining its Localization. *Jour. Infect. Dis.*, 1923, vol. xxxiii, pp. 248-268.
- ³⁴ Turck, F. B.: Ulcer of the Stomach: Pathogenesis and Pathology. *Jour. Am. Med. Assn.*, 1906, vol. xlv, pp. 1753-1763.
- ³⁵ Vedova, R. D.: Ricerche sperimentali sulla patogenesi dell' ulcera gastrica. *Suppl. Policlin.*, 1900, vol. vi, pp. 1153-1156.
- ³⁶ Virchow, R.: Quoted by Bolton.
- ³⁷ Ziemssen, V.: Zur Technik der Localbehandlung des Magens. *Deutsch. Arch. f. klin. Med.*, 1872, vol. x, pp. 65-72.

BIBLIOGRAPHY—PART II

- ¹ Carman, R. D.: The Röntgen Diagnosis of Diseases of the Alimentary Canal. Philadelphia, W. B. Saunders Co., 1920, pp. 676.
- ² Mann, F. C., and Williamson, C. S.: The Experimental Production of Peptic Ulcer. *ANNALS OF SURGERY*, 1923, vol. lxxvii, pp. 409-422.
- ³ Mann, F. C.: The Chemical and Mechanical Factors in Experimentally Produced Peptic Ulcer. *Sur. Clin. N. Amer.*, 1925, vol. v, pp. 753-775.
- ⁴ Morton, C. B.: Observations on Peptic Ulcer. I. A Method of Producing Chronic Gastric Ulcer: A Consideration of Etiology. (In Press.)

BIBLIOGRAPHY—PART III

- ¹ Caylor, H. D.: The Healing of the Gastric Ulcer in Man. *ANNALS OF SURGERY*, 1926, vol. lxxxiii, pp. 350-356.

CHARLES BRUCE MORTON

- ² Kennedy, R. L. J.: Etiology and Healing Process of Duodenal Ulcer in Melena Neonatorum. *Am. Jour. Dis. Child.*, 1926, vol. xxxi, pp. 631-638.
- ³ Mann, F. C.: Production and Healing of Peptic Ulcer; an Experimental Study. *Minn. Med.*, 1925, vol. viii, pp. 638-640.
- ⁴ Mann, F. C.: The Chemical and Mechanical Factors in Experimentally Produced Peptic Ulcer. *Surg. Clin. N. Amer.*, 1925, vol. v, pp. 753-775.
- ⁵ Mann, F. C., and Williamson, C. S.: The Experimental Production of Peptic Ulcer. *ANNALS OF SURGERY*, 1923, vol. lxxvii, pp. 409-422.
- ⁶ Morton, C. B.: Observations on Peptic Ulcer. I. A Method of Producing Chronic Gastric Ulcer: A Consideration of Etiology. (In Press.)
- ⁷ Morton, C. B.: Observations on Peptic Ulcer. II. A Röntgenologic Study of Experimentally Produced Chronic Ulcers. (In Press.)

THE SURGICAL PATHOLOGY OF THE GALL-BLADDER *

BY VERNE G. BURDEN, M.D.

OF PHILADELPHIA, PA.

CHOLECYSTITIS as seen by the surgeon is one of a group of closely associated lesions which includes hepatitis, cholangitis, pancreatitis, appendicitis, and in many cases duodenal ulcer. These lesions, with the exception of ulcer and appendicitis, are in most instances complications and sequels of cholecystitis, and to them can be attributed most of the morbidity and mortality of the disease. Dysfunction of the gall-bladder may be the result of infectious, mechanical, chemical, metabolic, and nervous factors. The newer knowledge of disease of the biliary tract will come from an understanding of its innervation. There is in all likelihood a sphincteric mechanism under sympathetic control in the cystic duct as well as at the termination of the common duct disturbance of which may be a cause of disease in a manner similar to sphincter spasm in cases of cardiospasm, pylorospasm, Hirschsprung's disease, and many cases of idiopathic hydronephrosis. The exciting cause of cholecystitis is infection for which there are many predisposing factors of more or less importance. The fact that the greater number of patients having disease of the gall-bladder are entirely relieved of their symptoms after its removal, while many who have had only a drainage operation suffer a recurrence of symptoms, supports the belief that the gall-bladder regardless of the mechanism of its implication is the keystone of the situation. Cholecystitis in most instances is a chronic insidious process whose early symptoms are disregarded by the patient and often escape the attention of the physician.

The gall-bladder is attached to the under surface of the right lobe of the liver, hangs in a dependent position and empties above through the cystic duct. It always contains bile under variable tension and is never seen completely collapsed or empty. It has a rich blood supply from the cystic artery and from many small vessels in its attachment to the liver. The cut edge of the gall-bladder bleeds as freely as the incised intestine. Its abundant lymphatic supply has a free communication through its attachment to the liver, and with nodes in the hilus of the liver, at the juncture of the cystic and common ducts, along the common duct, and around the head of the pancreas and first portion of the duodenum. There are numerous lymphatic vessels in the wall of the gall-bladder and solitary lymph follicles have been seen in its mucosa.

The known functions of the gall-bladder have to do with the concentration and storage of bile, the secretion of mucus, and the regulation of pressure

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in the duct system. Its relations, if any, to digestion and to the metabolism of fat and cholesterol are not understood. No doubt more fluid leaves the gall-bladder by absorption through its wall than by way of the cystic duct. At operation it is often difficult and sometimes impossible to empty the distended gall-bladder by compression. The mere mechanical arrangement of the valves of Heister in the cystic duct does not adequately explain this fact and the likelihood of a sphincteric mechanism in the duct becomes more plausible. In operations under local anæsthesia the gall-bladder may be freely handled and compressed without causing much discomfort to the patient. Traction on the cystic duct causes pain and we have noted that under general anæsthesia traction on the gall-bladder preparatory to its removal sometimes caused reflex respiratory inhibition. The probable explanation of severe colic is strong muscle spasm in an inflamed gall-bladder or common duct when the outlet of either is obstructed.

Experimental cholecystitis has been produced by the injection of a large dose of a bacterial culture into the peripheral or portal circulation. That the gall-bladder is especially vulnerable to attack when the general circulation is loaded with infection is shown clinically in cases of typhoid fever and pneumonia. Direct introduction of bacteria into the lumen of the gall-bladder does not produce infection unless there is coincident obstruction. Rosenow produced cholecystitis by the intravenous injection of specific organisms and showed that the infection was interstitial. Mann produced, with regularity, a specific chemical cholecystitis by the intravenous injection of Dakin's solution and showed that the toxic agent, chlorine, reached the gall-bladder by way of the blood-vessels in its attachment to the liver. The reaction is practically confined to the gall-bladder, the ducts are not affected; the inflammation is intense and is caused by engorgement and rupture of the lymphatics with extravasation of blood. The mucosa is only slightly changed. The acute reaction which appears in from twelve to twenty-four hours may last for several weeks and after three months the gall-bladder may appear normal except for a few small white scars. Sometimes the condition becomes chronic.

The frequent association of hepatitis and cholecystitis is significant, but the evidence at hand does not warrant the conclusion that the usual route of infection is from the liver by way of the lymphatics. That the gall-bladder is often the primary seat of infection is indicated by the good results which follow cholecystectomy; by the fact that the portion of the liver adjacent to the gall-bladder is the area most frequently and characteristically affected in cholecystitis; and by the fact that marked hepatitis may exist with only slight inflammation of the gall-bladder and yet in severe cholecystitis the liver is often grossly normal. From experience in the operating room it would seem that cholecystitis is secondary to hepatitis in some instances, but primary infection of the gall-bladder with secondary hepatitis is more common. The importance of this conception is obvious from the standpoints of treatment and prognosis. The possibility of ascending infection in the wall of the common duct must be admitted, but there are few data on which

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to base an opinion. Inflammatory reaction in the wall of the common duct was present in nearly all of a series of necropsy specimens from cases of cholecystitis. Since this reaction was most apparent in the region of the cystic duct juncture, it probably indicated extension from the gall-bladder. Pancreatitis when it affects the head of the gland or the triangle of infection is usually secondary to cholecystitis. There is ample clinical evidence of the relation between appendicitis and cholecystitis, especially in female patients. In many cases of duodenal ulcer there is also disease of the gall-bladder, which if not recognized and treated, may be the cause of post-operative symptoms.

Does the infected gall-bladder ever return to normal? It is probable that mild degrees of inflammation may undergo complete resolution; but cholecystitis when recognized clinically probably continues as persistent or recurrent inflammation with mild or severe exacerbations. The structural effects, derangement of function, and potential complications represent distinct liabilities when the damaged organ is allowed to remain. Gall-stones, especially when multiple, are most often a complication and result of cholecystitis. The single cholesterol stone, it may be granted, is a product of perverted metabolism. Practically all gall-stones are formed in the gall-bladder; only rarely do they originate within the intrahepatic ducts. Mild cholecystitis occurs with or without stones, but advanced chronic inflammation of the gall-bladder is nearly always accompanied by stones. The calculi sometimes form in crops and the same gall-bladder may contain several crops which vary in size, shape, and often in composition. The facets are caused by pressure and not by friction. The nuclei of stones often contain dead or living bacteria, and it has been shown that bacteria can penetrate a sterile gall-stone.

Will gall-stones dissolve in bile? Several varieties of gall-stones were placed in bottles to which were added bile obtained in some instances from the same gall-bladder as the stone and in other instances from foreign gall-bladders with and without stones. The bottles were sealed and kept at room temperature for one year without evidence that the gall-stones had dissolved.

Stones rarely originate in the common duct probably because its lumen is constantly flushed by bile. Stones enter the duct from the gall-bladder and cystic duct and if retained increase in size. The presence of a stone in the duct always causes more or less obstruction and inflammation, factors which favor the formation of stones. Therefore, it seems probable that some of the multiple stones found in the common duct were actually formed there.

The appearance of the gall-bladder *in situ* is peculiarly deceptive in its relation to clinical symptoms. Marked evidence of disease is often seen with only a few indefinite complaints, while a gall-bladder apparently normal in appearance but showing microscopic lesions may be the cause of repeated and severe attacks of pain and even jaundice. On what evidence do we base the diagnosis of disease of the gall-bladder when the abdomen is opened? There may be no gross indication of disease, and it is here that

experience has taught that if the clinical history is reliable and a verdict has been made against the gall-bladder, it should be removed. In these specimens there is always microscopic evidence of disease and the patients are relieved of their symptoms. Contributory signs in the diagnosis of cholecystitis are, the appearance of the liver, especially when that portion overlying the gall-bladder is gray, firm and contracted with radiating lines of fibrous tissue the result of hepatitis; changes in size of the glands along the cystic and common ducts, and the condition of the head of the pancreas. The appearance of the gall-bladder itself, except when grossly diseased, is not always reliable. The normal blue color may exist in the presence of infection and a deposit of fat beneath the serosa may or may not be indicative of disease. More can be learned by the sense of touch because when thickening and induration of the walls are detected there is likely to be inflammation. Small stones when present may be missed if the gall-bladder is distended and small ones in the cystic duct often escape detection. The presence of pericholecystic adhesions, whether to omentum, duodenum, or colon, is usually diagnostic of cholecystitis.

The material for this study was obtained from 112 consecutive cholecystectomies performed by surgeons at the Mayo Clinic. Within one or two minutes after the gall-bladder was removed its gross appearance was noted; it was then opened and the character of its interior and contents observed. Several sections were removed from the wall and immediately cut on the freezing microtome, stained and mounted. In the meantime the gall-bladder was studied under the dissecting microscope. Fresh material is particularly desirable for studying the gall-bladder because specimens obtained at necropsy are unsuitable for histologic study owing to the rapid changes which take place even within several hours after death. Much of the current opinion regarding the pathology of the gall-bladder is based on a study of necropsy specimens. Sixty per cent. of the specimens contained stones, of which 22 per cent. were single. The cystic duct contained stones in 11.6 per cent. and in more than 15 per cent. of the cases with stones in the gall-bladder they were also found in the cystic duct. The removal of stones from the cystic duct will usually require cholecystectomy; any other procedure aimed at saving the gall-bladder inflicts damaging traumatism on the cystic duct and invites the possibility of injury to the hepatic or common duct.

When stones are not present the thickness of the wall as determined by palpation is the most constant criterion of disease. The wall of the normal gall-bladder is thin, translucent, and, *in situ*, has a greenish-blue color imparted to it by the contained bile.

Bile becomes concentrated when it remains in the gall-bladder for even a short time. Inflammation may increase the secretion of mucus and in cases of obstruction forms the so-called white bile which is nearly always accompanied by stones. According to my observations, the bile in diseased gall-bladders is more often thick and concentrated than thin and watery, and sections from the wall usually show the lining epithelium intact unless the

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organ is grossly destroyed. The concentrating power of the gall-bladder evidently is not much impaired in chronic cholecystitis.

The contracted fibrous gall-bladder contains stones in nearly every case or the stone has passed out into the common duct.

Papilloma of the gall-bladder, usually multiple, occurs as a small pale protuberance from the mucosa and was found in 3.5 per cent. of the specimens. It cannot be detected until the gall-bladder has been opened and under the microscope appears as a simple elongated growth of mucosa. It is not malignant, but may be potentially so.

Hydrops of the gall-bladder is the result of intermittent obstruction usually by a single cholesterol stone, to which other stones may later be added. Complete obstruction causes atrophy of the gall-bladder. In hydrops the organ is distended, pale, and contains in addition to one or more stones watery mucus sometimes tinged with bile. The wall is markedly thickened and trabeculated. The microscope reveals loss of the villous appearance of the mucosa, low cuboidal or flat cells in place of the normal tall columnar epithelium of the mucosa, an increase in the number of goblet cells, proliferation of the glands of the mucosa and submucosa, cedema, congestion and inflammatory exudate in the wall, and always a marked increase in the amount of muscular tissue.

The "strawberry" gall-bladder, first described by Moynihan and MacCarty in 1910, derives its name from the speckled sulphur yellow appearance of the mucosa which in thin specimens is easily seen before the gall-bladder is removed. Sections stained by Sudan III reveal that the yellow appearance is caused by a substance which occurs in finely divided particles at the tips and bases of the columnar cells of the mucosa and in large cells of the submucosa. It is also said to occur in the walls of the blood-vessels of the gall-bladder. Chemically, it is a lipoid material, an ester of cholesterol. The quantity of lipoid varies in different specimens from amounts which almost fill the villi and give to the mucosa a brilliant yellow appearance to amounts so small that they can be detected only by the dissecting microscope or by special stains. The significance of the lipoid substance is not known, but probably it has some relation to the metabolism of fat and cholesterol, and therefore, we cannot estimate its pathologic importance except to state that it does not occur in the normal gall-bladder. Twenty per cent. of this series of specimens were "strawberry" gall-bladders; they all showed inflammatory lesions, and fifty per cent. contained stones.

When the fresh gall-bladder is placed in water under the dissecting microscope one sees tall, delicate, interlacing folds enclosing polygonal spaces, and on the pellucid tips of these folds the fine blood-vessels can be traced. The arrangement of the mucosa provides an enormous surface area which makes possible the great absorptive power of the gall-bladder. The early changes in cholecystitis as cedema, congestion, hypertrophy, cholesterol deposit, papilloma, and ulceration can be detected in these folds of mucous membrane.

Microscopic sections through the wall reveal five layers, mucosa, sub-

mucosa, muscle, subserosa, and serosa or peritoneal covering. In my experience, the early lesions of chronic cholecystitis occur in the mucosa and submucosa and are characterized by congestion, oedema, and round-cell infiltration of the villi. The lining epithelium rarely desquamates. The results of experimental work show that infection may travel by the lymphatics from the liver to the outer coats of the gall-bladder, that hæmatogenous infection is usually interstitial, and that in chlorine cholecystitis the mucosal side is only slightly affected. However, the examination of specimens removed at operation showed that the mucosa and submucosa were the areas first involved. One rarely sees inflammation deep in the wall without involvement of the submucosa while the contrary is a common finding. The villi often elongate and interlace in a luxuriant fashion. They may be swollen and congested or they may have disappeared entirely, leaving a surface covered by flat epithelium or by hyaline fibrous tissue. The inflammation later extends through the wall of the viscus and becomes established in the deeper coats and in these specimens one can see that the inflammatory reaction diminishes from mucosa to serosa. The discrepancy between the clinical and experimental lesions may indicate that the pathway of infection is different.

In the submucosa of the normal gall-bladder are found clusters of mucous glands which were first described by Luschka in 1858. They are always present, but their number is greatly increased when the gall-bladder is diseased. They occur in two forms. In one they appear as simple clusters of mucous glands in the mucosa, submucosa, and sometimes deeper in the wall. In the other they lose their glandular appearance and show as deep crypts or diverticula which drop down through the mucosa and muscular layers and come to lie just beneath the serous covering of the gall-bladder. These crypts are lined by columnar epithelium similar to that covering the mucosa, they are in free communication with the interior of the gall-bladder and often contain bile. They sometimes fill with inspissated bile and become cystic, or they may be the birthplace of calculi in which case the condition spoken of as honeycomb gall-bladder is produced in which the stones seem buried in the wall. Many instances have been observed of crypts surrounded by a dense mass of small round cells and other signs of inflammation, so that the picture resembled a true intramural diverticulitis, and in such cases there were usually many adhesions to the gall-bladder. From these observations it seems likely that diverticulitis of the gall-bladder is the cause of pericholecystitis, that it represents the process by which slow perforation into neighboring viscera occurs with the formation of fistula; that rupture of one or more of these diverticula may explain many cases of bile peritonitis in which no gross opening in the biliary tract can be found. The glands and diverticula show a tendency to proliferate and become more numerous when stones are present in the gall-bladder so that it becomes necessary to distinguish this condition from carcinoma. In many cases where experimental cancer of the gall-bladder is said to have been produced by the introduction of foreign material,

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the condition may not be cancer at all, but only a benign proliferation of these glands the result of foreign body irritation.

The normal gall-bladder has a well-developed musculature which is made up of more or less isolated bundles arranged in two or more directions. No one has ever seen the human gall-bladder contract so that the muscle probably serves to maintain a condition of tonus. That the muscle by contraction acts to empty the gall-bladder of its contents seems to be established by the following observations. A characteristic feature of chronic cholecystitis is muscular hypertrophy which is especially notable when stones are present. The muscle bundles enlarge and may make up almost the entire thickness of the wall. The bundles may be separated by œdema and round-cell infiltration and sometimes they are split into fibres by inflammatory exudate. Frequently in specimens which contain stones, and especially if there has been obstruction and the presence of white bile, the gall-bladder when opened displays an appearance of trabeculation. This is characterized by the presence of ridges or bands which run and cross in several directions in a manner similar to trabeculation seen so commonly in chronic obstruction of the urinary bladder. In the latter instance it is well known that the trabeculated appearance is caused by hypertrophy of muscle bundles in the effort to empty the bladder against obstruction by stone, tumor, or stricture. In the interstices between the hypertrophied bundles small pockets or cellules are formed. Trabeculation of the gall-bladder is analogous in every way. Microscopic examination reveals that the bands are not made up of fibrous tissue, but represent large muscle bundles over which the mucosa is stretched, so that the villi or rugæ and most of the submucosa have disappeared, leaving a single layer of cuboidal or sometimes flat epithelium lying almost directly upon the muscular coat. At intervals, deep crypts may be seen penetrating between the muscle bundles. This hypertrophy should dispel any doubt of the importance and activity of the muscle of the gall-bladder whether in health or disease.

The subserous layer is made up of connective tissue, fat, lymphatics, and blood-vessels. The principal pathologic changes are congestion, œdema, and round-cell infiltration.

There were no specimens of acute cholecystitis in this series. Lesions of an acute nature as ulceration and free pus are more active stages of a chronic process. Gangrene, proven by microscopic examination, is very rare because of the rich and double source of blood supply, and when it does occur is usually the result of a diffuse infectious thrombosis of the main vessels in the wall of the gall-bladder. Acute cholecystitis is a clinical entity that is not often verified by the finding of acute lesions in the gall-bladder at operation.

Carcinoma was not found in any specimen. During the period when this study was made, four cases of carcinoma of the gall-bladder were encountered at operation, specimens were removed to confirm the diagnosis and in one case gall-stones were removed, but in all the condition was too far advanced for cholecystectomy. In a series of 10,126 gall-bladders removed at the Mayo

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Clinic, 44 were reported adenocarcinoma, two epithelioma, and one lymphosarcoma. This does not represent the incidence of carcinoma because only rarely is a carcinomatous gall-bladder removed. In one instance adenocarcinoma and epithelioma were found in a removed gall-bladder. The patient was operated on again over two years later because of biliary obstruction, at which time there was no evidence of a common duct and a careful search, both gross and microscopic, failed to reveal carcinomatous tissue.

Stones are present in nearly 90 per cent. of the malignant cases and this fact has led some to believe that they are the etiologic factor. The tumor grows into the liver and ducts by extension, but metastasis to distant parts is rare, probably because of the rapidly fatal issue from biliary obstruction.

CONCLUSIONS

The pathology of chronic cholecystitis has been studied in 112 surgical specimens by immediate examination in the gross and in frozen sections. The condition is usually not the result of an acute process, but it begins as a mild infection and inflammation of the mucosa and submucosa and progresses deeper into the wall of the viscus where it becomes established around glands, crypts and diverticula and between the muscle bundles. Its chronicity is fostered by the anatomic and histologic structure of the organ which favor stasis and obstruction. Attention is directed to the frequent presence of intramural diverticula and their relation to infection, stone formation, perforation, and pericholecystitis. The muscle of the gall-bladder plays an active part in its normal function and undergoes characteristic changes when the outlet of the viscus is intermittently or partially obstructed. Stones are often a complication of cholecystitis and usually an inevitable result of long-continued infection, but they may also form in the early stages of inflammation. Cholecystitis is usually a primary infection and cholecystectomy is a logical procedure because it removes the focus from which the attending and complicating lesions of cholecystitis derive their origin. Cases not relieved by cholecystectomy are probably instances of primary hepatic or pancreatic infection in which the gall-bladder has become secondarily involved, or the infection has so established itself that removal of the focus is without effect.

GALL-BLADDER TECHNIC

BY JOSEPH L. DECOURCY, M.D.

OF CINCINNATI, OHIO

IT IS not within the province of this paper to discuss cholecystostomy *versus* cholecystectomy, although it may not be amiss to voice an opinion in this regard. Of four hundred gall-bladder operations performed at the DeCourcy Clinic and followed every six months with follow-up circulars, it was found that:

First.—Recurrence of colic (stone) was much more frequent following cholecystostomy and was very unusual following cholecystectomy.

Second.—Indigestion and flatus frequently persisted following gall-bladder drainage and disappeared in practically every instance following gall-bladder removal. This would argue that hepatitis, which is frequently present, disappears more rapidly following removal of an infected gall-bladder than

Third.—Post-operative convalescence is more rapid and smoother following drainage.

Fourth.—Preservation of bile is important. Prolonged deviation of bile from the intestinal canal, results in a distorted digestion, headaches, dehydration and so on.

Fifth.—The immediate mortality is just as low following cholecystectomy as following cholecystostomy, with the possible exception of acute empyema, in which we still prefer drainage first with removal later.

In gall-bladder disorders the pathology is primarily in the gall-bladder. Hepatitis and duct involvement are usually secondary.

It is not at present known whether stones can form in the biliary ducts.

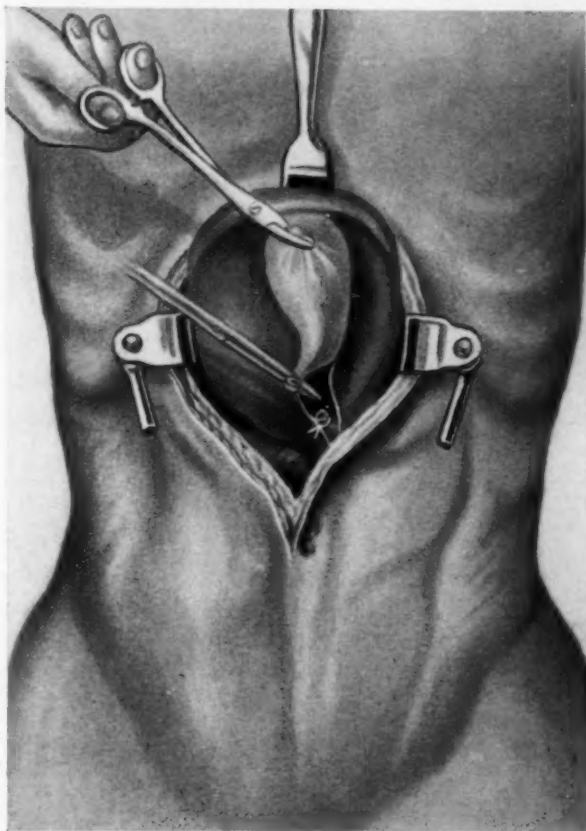


FIG. 1.—Eventration of liver by traction on gall-bladder for exposure of ducts.

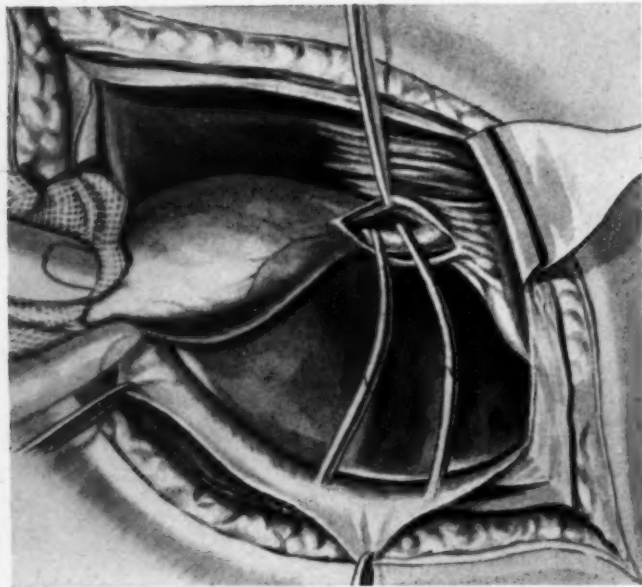


FIG. 2.—Clamping of cystic duct and artery.

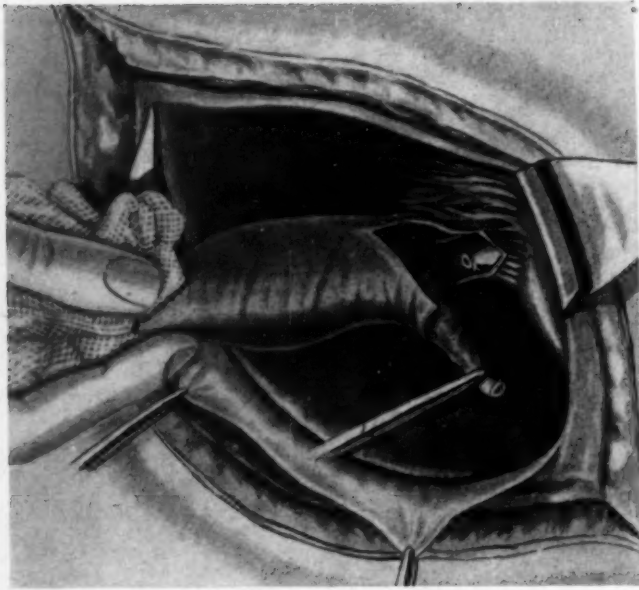


FIG. 3.—Enucleation of gall-bladder from below upward.

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Stones have been found completely imbedded in the walls of the gall-bladder which could not possibly have been removed by drainage or curettement.

From the pathological viewpoint it is therefore better surgery to remove the larger majority of diseased gall-bladders.

Physiologically we may be wrong.

Practically, however, we now know that persons are just as normal following the removal of their gall-bladders as they were before, and it is questionable in my mind whether a drained gall-bladder, formerly diseased, ever functions normally.

From a technical viewpoint there still arises the question whether a gall-bladder should be removed from below upward or from above downward.

For a number of years I removed all gall-bladders from above downward, feeling that I could accomplish this operation more readily than from below upward. After improving my technic, however, I soon began removing all from below upward and found this way to have the following advantages:

First.—The blood supply to the field of operation is controlled early in the operation, thus giving a field clear for dissection, thereby enabling us to avoid injury to common duct.

Second.—In removing a gall-bladder from above downward, infection and stones may be pushed into the ducts and may later escape our attention.

Third.—When removing from below upward, the gall-bladder can be used for traction, thus giving better exposure and in many cases giving us a field almost entirely out of the abdominal cavity.

Fourth.—In removing from above downward, the incision was usually



FIG. 4.—Raw surfaces sutured over with peritoneum.

carried down to the muscular coat of the gall-bladder and the stripping continued in this plane.

From recent experiments we have found that the infection frequently penetrates the peritoneal covering of the gall-bladder and unless this is removed, some of the infection may remain. This is further enhanced by the fact that we almost always find adhesions of surrounding structures to the gall-bladder when diseased.

Our operation consists of a longitudinal incision, slightly inside the

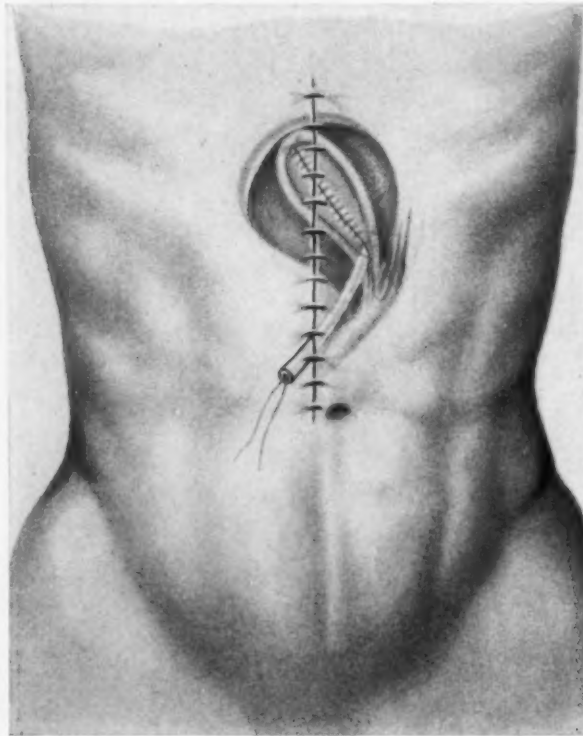


FIG. 5.—Finished operation with tube to cystic duct.

outer border and extending from the costal margin to below the umbilicus. A self-retaining retractor is then introduced with another hand retractor following upward under the costal margin.

The gall-bladder is next explored with the surrounding structure, stomach, pancreas, etc., but is not opened.

If removal is decided upon, the gall-bladder rest under the patient is elevated about four inches. (We have also occasionally placed the patient in a reversed Trendelenburg posture but have not made it a routine.) Back rest is usually sufficient.

The gall-bladder is next grasped with a small Kelly forceps. A forceps with teeth cannot be used. With traction the gall-bladder is pulled outward and upward, bringing the liver with it. This can be accomplished in at least nine out of every ten cases. Occasionally we find a gall-bladder so friable or so distended that this cannot be accomplished. In these cases sufficient traction can usually be made with the hand.

After elevating the gall-bladder the cystic duct is exposed and isolated with blunt dissection. The tissues surrounding the cystic duct are usually very friable and can be easily separated from the duct with the aid of a hæmostat, entering the tissues and there separating the blades. The duct should be entirely isolated from all surrounding structures before it is tied. We have found that since we are doing this that we do not have any

GALL-BLADDER TECHNIC

drainage later. If fat, etc., is included in the ligature, drainage usually occurs. The duct is tied with number three chromic gut and the ends of suture left long.

The cystic artery is next grasped and ligated and allowed to drop into the wound.

The gall-bladder is then stripped upward with sharp dissection, leaving a little peritoneum on either side and suturing these over the raw surfaces of the liver as the gall-bladder is removed.

A quarter-inch tube is now passed over the catgut on the cystic duct and passed down lightly to the duct. This tube is not anchored to the abdominal wall.

The abdominal incision is now closed.

If one observes closely, it will be seen that the cystic duct enters the common duct from the back, rather than into the anterior or side portion, as we would suspect. One must be very careful therefore not to injure the common duct. This is best accomplished by blunt dissection and complete isolation of the cystic duct. I believe that when the duct is injured it is usually done so by blind grasping with forceps and ligation *en masse*.

The sutures on the cystic duct are allowed to protrude from the abdominal wound so that if symptoms of common duct obstruction occur, due to inflammatory swelling or overlooked stone, they may be followed down and the duct easily opened.

ULCER OF MECKEL'S DIVERTICULUM AS A CAUSE OF INTESTINAL HEMORRHAGE*

By ARNOLD S. JACKSON, M.D.

OF MADISON, WIS.

FROM THE JACKSON CLINIC

MECKEL'S diverticulum is responsible for many serious and frequently unrecognized abdominal complications. The literature contains too many reports from the autopsy room. With increasing knowledge on the part of the general practitioners of the possible surgical complications that may arise from this embryologic anomaly, there should result a marked reduction in the mortality rate in these cases. Heretofore a diagnosis has often been made too late for successful surgical intervention. Among the various pathologic conditions that may occur in Meckel's diverticulum are intestinal obstruction, intussusception and volvulus, diverticulitis, ulceration tending to perforation with peritonitis, fistulas, suppuration, gangrene, hernia, cysts, tumors (benign and malignant), tuberculosis and hemorrhage. It is with hemorrhage that this report is concerned.

Judging from the literature, hemorrhage from Meckel's diverticulum is a rare complication, and as shown by the chart, only eight cases were found. The fact, however, that two patients with this condition were referred to the Jackson Clinic by the same physician within a decade, leads to the assumption that many more cases have occurred, and were either not recognized or not reported. The clinical symptoms so closely paralleled each other in these two cases as to enable the family physician, Dr. E. A. Ketterer, of Montfort, Wis., to make a correct tentative diagnosis in the second patient. The history and findings in the latter case were so similar to the published report of the first patient that we were led to concur with the physician's opinion. It is rather remarkable that this correct pre-operative diagnosis, the first of its kind to be reported, should have been made in a farm house by a so-called "country doctor." The history and findings were as follows:

M. O., a boy aged fourteen years, was seized with severe generalized abdominal cramps following the eating of green apples four days previous. A physician was called and diagnosed the condition as green apple colic. The boy was relieved of the pain with sedatives, but became progressively weaker. On the third day considerable bright blood containing many clots was passed from the rectum. At no time did vomiting occur. Another physician, Dr. E. A. Ketterer, was called. He observed the further passage of several pints of blood varying in color from maroon to bright red. Noticing the marked anemia, progressive weakness, and absence of general physical signs, except slight tenderness in the right lower quadrant, he was vividly reminded of the clinical picture of a similar case,[†] and made a diagnosis of intestinal hemorrhage from Meckel's diverticulum.

* Presented at the Annual Alumni Meeting of the Mayo Foundation, October 6, 7, 8, 1926, Rochester, Minn.

† The former patient was operated upon and the findings reported by Dr. R. H. Jackson. The article appeared in the *ANNALS OF SURGERY* and was the first report of such a case that we found in the literature of this country.

ULCER OF MECKEL'S DIVERTICULUM

Several hours later Dr. J. Hurlbut and I saw the boy. Temporary measures had been used to improve the general condition, but the hemorrhages had continued and we were shown several vessels full of blood. The physician reported an improvement in the pulse, which now was 120 and of poor quality. The boy appeared extremely anæmic, was very weak, and showed an anxious, rather pinched facies. He responded freely to questions, but was nervous and restless. Except for the anæmia and dryness of the tongue and skin, the general physical examination was negative, save for a slight tenderness in the right lower quadrant. The blood-pressure showed 124-50. Heart sounds were fair. The question of keeping the patient at the farm house with only meagre facilities or of transporting him to a hospital ended in the latter decision. Less than an hour remained in which to improve his condition and to transport him several miles over a hilly country to catch the daily train. Five hundred c.c. of glucose and five units of insulin were given intravenously. In our experience this is an excellent temporary restorative in cases of severe shock or hemorrhage. A slight reaction was followed by a steady improvement, and against the father's wishes, who felt that the boy would not survive, the trip was started. On reaching town ahead of the train it was decided to continue by auto the remaining sixty miles.

We believed that the saving of time was of more importance than the added risk of jolting. At the end of the journey the patient was taken at once to the Clinic, where his blood was grouped and a count made. The hæmoglobin was 12 per cent., and red blood-cells 1,210,000, blood group IV. A blood transfusion by the citrate method was given immediately at the hospital by Doctor Hurlbut. The boy went into complete collapse, the pulse being scarcely perceptible. The usual emergency methods were used, but the best response was obtained from the use of glucose-insulin intravenously, following the transfusion of the 500 c.c. of blood. The patient remained in a semi-conscious state for two hours, and then slowly improved. Mild delirium followed the administration of whiskey, but sleep was induced by morphine. Fibrinogen was given subcutaneously and orally in maximum doses, and was continued for four days. The following day the blood picture was slightly improved as shown by the chart, and another blood transfusion was given. This was followed by a third transfusion during the week until the hæmoglobin registered 70 per cent., and the red blood-cells 2,620,000. The general condition steadily improved so that he was able to be up and around at the end of a week. The gastro-intestinal tract was kept at absolute rest for three days, and after the first twenty-four hours no further intestinal hemorrhages were observed. The advisability of a röntgenological study was considered, but was not made for fear of starting the hemorrhage anew. Digital rectal examination was negative.

Operation.—A subumbilical right rectus incision was made, and a small amount of

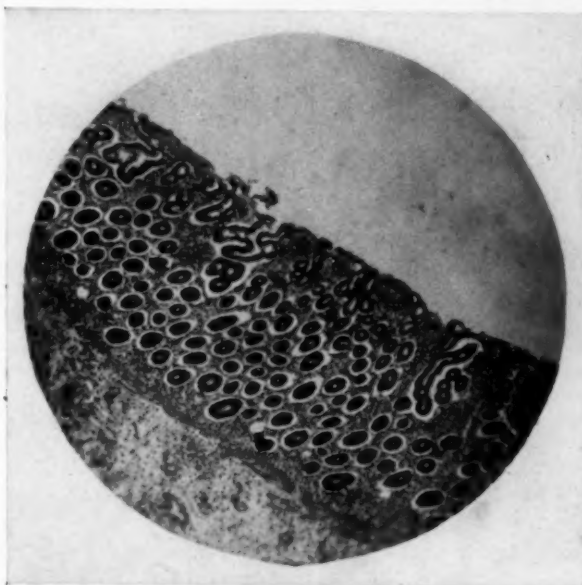


FIG. 1.—Area of aberrant gastric mucosa showing typical gastric glands.

straw-colored fluid in the abdominal cavity allowed to escape. The terminal ileum was located and about 40 cm. above the cæcum was found a Meckel's diverticulum 3 by 8 cm. The distal end was free and there was no visible or palpable evidence of hemorrhage. Branches of the omphalo-mesenteric artery were distended and these were separately ligated. A further search of the other abdominal viscera revealed no pathological lesions with the exception of the appendix, which contained several fecal concretions and was slightly swollen. Appendectomy was performed. Rubber-covered clamps were then applied to the ileum above and below the diverticulum to guard against soiling. The diverticulum was excised by means of an elliptic incision, the axis of which was

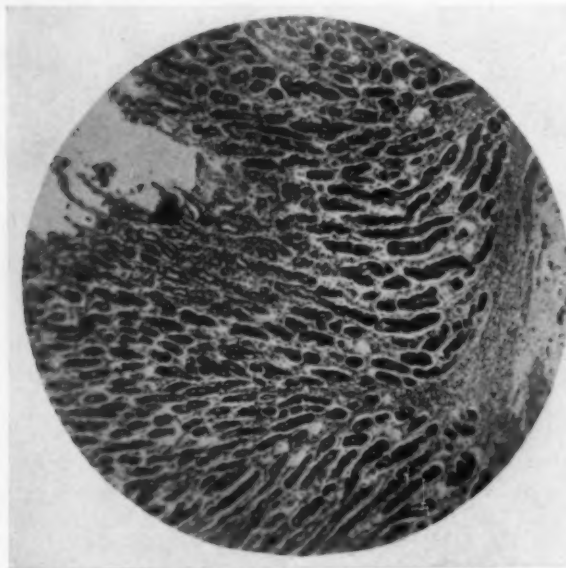


FIG. 2.—Characteristic gastric mucosa adjacent to area shown in Fig. 1.

made transverse in order not to reduce the lumen of the bowel in suturing. The margins of the incision were closed by a through-and-through suture of dulox. This was reinforced by several stay sutures of silk. As the base of the walls of the diverticulum at its junction with the ileum were not indurated, a simple excision was sufficient. When marked induration exists at this point, a resection of the adjacent section of the ileum may be advisable, as was done by R. H. Jackson in his case.

Convalescence was uneventful and the case was discharged from the hospital on the tenth day. One month later the patient returned for observation and presented an

entirely different picture. He had gained ten pounds in weight and was rosy-checked. The blood count as seen from the chart was normal.

The chief point of interest in the pathology of hemorrhagic ulcer of Meckel's diverticulum concerns the presence in the affected diverticulum of areas of aberrant gastric mucosa with pyloric, Brunner's, and fundus glands. (Stulz and Woring.) The histological picture of the ulcer is that of gastric or duodenal ulcer, or better still, that of peptic ulcer of jejunum following gastro-enterostomy. (Hubschmann.) It is enough to say that Meckel's diverticulum, whether with a total or only a partial coating of gastric mucosa, can and does behave like a miniature stomach. (Guibal.)

Stulz and Woring point out that there is a definite analogy between the peptic ulcer as seen in Meckel's diverticulum, and that of the stomach, and that a further study of the former may throw some light on the origin of peptic ulcer in general.

Examination of this specimen at the time of operation revealed a puckering near the distal end (as seen in the photograph) that resembled a small ulcer. The pathological examination, as made by Dr. C. H. Bunting, showed

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the presence of the characteristic areas of gastric mucosa, and an area of ulceration.

Review of the Literature.—A study of the cases heretofore reported of ulcer of Meckel's diverticulum in which hemorrhage is the predominate symptom reveals the following: Of the eight cases three have been reported in this country and the others abroad. Seven of the patients have been males. With the exception of one case, hemorrhage has occurred either in infancy or childhood in every instance. Our patient may be said to be the only acute case, the others being characterized by severe hemorrhages followed by periods of remission. The outstanding symptom is the frequent repetition of profuse intestinal hemorrhages. The blood may be either bright red or maroon or tarry. Clots may be present, but mucus as seen in dysentery or intussusception is absent. Excision or resection of the diverticulum stopped the hemorrhages and affected a cure in every case. Pain may or may not be present. Colics appeared in several cases. Abdominal examination is usually negative.



FIG. 3.—Area of ulceration. The base of the ulcer is made up of a layer of connective tissue infiltrated with polymorphonuclear leucocytes and lymphocytes. Some gastric glands appear at the edge of the ulcer.

The literature contains reports of several more cases of ulcer of Meckel's diverticulum in which hemorrhage occurred, but in which the main picture was one of perforation with peritonitis. Stulz and Woringner have recently published an excellent summary of these cases. We have observed or know of other cases of this type, but in these, surgery was indicated for the relief of perforation and not hemorrhage.

NOTE.—Callendar, G. R.: *Am. J. M. Sc.*, July, 1915. The autopsy report of a child who had died from intestinal hemorrhage is given. An ulcer of the ileum extending to the border of a Meckel's diverticulum was found. Gastric glands were present in the diverticulum. No clinical history was given. Another case in which we were unable to trace the record is that of Griffith as quoted by Abt and Strauss.

NOTE.—At the 1926 meeting of the American Medical Association in the discussion following the paper of Doctors Abt and Strauss on this subject, the following physicians reported having observed cases: Dr. C. V. Moore, Portland, and Dr. J. B. Stone, Richmond. The cases of Doctors Neff and Schultz did not directly pertain to the subject of this paper inasmuch as the complications of perforation and intussusception occurred.

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In considering the differential diagnosis it may be necessary to rule out intussusception. In this condition only a small amount of blood is passed, and symptoms of intestinal obstruction may be present. A mass may usually be palpated abdominally or by rectum. Pain recurs paroxysmally every few minutes. Vomiting is first of the contents of the stomach and later bilious. The chronic type of hemorrhagic ulcer of Meckel's diverticulum offers more of a diagnostic problem. Both conditions may occur during infancy, although the youngest patient with hemorrhagic ulcer was nearly a year old. In both instances the male sex is most often affected.

In conclusion, I believe that it is well to point out that this unusual condition is probably not as rare as has been generally supposed. That in any case of severe intestinal hemorrhage, especially if occurring in young boys, a hemorrhagic ulcer of Meckel's diverticulum should be suspected. As pointed out by other writers, delay in cases of ulcer of this kind may lead to perforation with peritonitis. We feel fortunate in having had the facilities to build up our patient to a condition in which operation was performed with comparative safety.

TABLE I

Reported Cases of Hemorrhagic Ulcer of Meckel's Diverticulum

Date	Age	Sex	Duration	Symptoms	Treatment	Result	Author
1903	18	M	14 yrs.	Bloody stools Pain rt. l. q.	Resection of Diverticulum	Recovery	Hilgenreiner
1922	28	M	24 yrs.	Bloody stools Abdominal pain	Resection of Diverticulum	Cured	Megevaud Dunant
1924	10	M	4 yrs.	Bloody stools Colic pains left l. q.—vomiting	Resection of Diverticulum and 12 cm. of ileum	Cured	Jackson, R. H.
1924	14	M	6 mos.	Bloody stools	Excision of Diverticulum	Recovery	Guibal
1925	41	M		Bloody and Purulent stools Abdominal colic	Excision	Cured	Pascale
1926	11 mos.	M	2 mos.	Bloody stools Fever—vomiting	Resection of	Recovery	Abt and Strauss
1926	2	F	4 mos.	Tarry stools Abdominal cramps	Resection of Diverticulum	Recovery	Abt and Strauss
1926	11	M	2 mos.	Black stools	Resection of Diverticulum	Recovery	Abt and Strauss
1926	14	M	6 days	Bloody stools Abdominal colic	Resection of Diverticulum	Cured	Jackson, A. S.

BIBLIOGRAPHY

- Hilgenreiner: *Beiträge z. clin. Chirurgie*, 1903, vol. xl, pp. 99-135.
 Jackson, R. H.: *ANNALS OF SURGERY*, 1924, vol. lxxx, pp. 222-224.
 Megevaud et Dunant: *Revue de Chirurgie*, 1922, vol. lx, pp. 536-552.
 Guibal: *Bull. et Mém. de la Soc. de Chirurgie de Paris*, 1924, vol. 1, pp. 349-355.
 Pascale: *La Reforma Medica*, August 3, 1925, pp. 721-724.
 Stulz and Woring: *ANNALS OF SURGERY*, 1926, vol. lxxxiii, pp. 470-478.
 Abt and Strauss: *The J. A. M. A.*, September 25, 1926, vol. lxxxvii, No. 13, pp. 991-996.

CHILLS IN ACUTE APPENDICITIS *

AN ANALYSIS OF 2841 CASES OF ACUTE APPENDICITIS TREATED IN MT. SINAI
HOSPITAL OF NEW YORK CITY

BY RALPH COLP, M.D.

OF NEW YORK, N. Y.

THAT the death rate in acute appendicitis has been materially lowered in the past decade is definitely established. Still it is far from inconsequential. Recent papers on the subject by Deaver and Magoun,¹ Gatch and Durman,² strongly emphasize that this particular surgical problem is not yet solved. While the clinical side has been studied quite carefully, certain symptoms remain which will bear more thorough investigation. The incidence and significance of chills is still obscure. It is of extreme importance to inquire routinely concerning this symptom in all cases, for it has more than an academic value. A review of what the various authorities have written on this subject will be of interest.

Gerster³ stated, "the occurrence of a chill is of gravest import and should be considered to constitute a more urgent indication to operate than even the signs of local peritonitis." Deaver⁴ writes, "chills are a rather uncommon occurrence in appendicitis, yet if at the onset of the attack they occur in rapid succession, and are accompanied by a temperature, they indicate a rapidly developing gangrene of the appendix. The opinion commonly entertained that the development of a peri-appendicular abscess is attended with chills is fallacious. Chills occurring on the second or third day of the attack and associated with high fever, sweating, a cold, clammy skin, indicate the development of metastatic or embolic abscesses. In neurotic patients a chill may be experienced and be of no moment." Fowler⁵ says, "the occurrence of a chill in the first stages of the disease is only occasionally noted, even in cases of more than usual severity. In certain cases it marks the occurrence of suppuration. Neither the severity of the primary attack nor the gravity of the subsequent lesions seem to bear more than a casual relation to the occurrence of the pronounced character of this symptom." According to Kelly and Hurdon,⁶ "chills are exceptional in cases of simple diffuse inflammation but are not rare with severe lesions. Of the cases of acute appendicitis not associated with abscess or general peritonitis admitted to the Johns Hopkins Hospital, 15 per cent. of them gave a history of chills, and in all of these, with the exception of two, the appendix was gangrenous or perforated or distended with pus. In the two cases showing slight lesions there were merely chilly sensations, which in one were probably accounted for by the presence of oxyurides, associated with high temperature. In three cases the chills occurred at the onset. In one the patient who had gone to

* Read before the Surgical Section at New York Academy of Medicine, December 3, 1926.

bed well, was awakened with a severe chill. More frequently the chill occurred several hours or a day or two after the onset. But 50 per cent. of the cases of diffuse or generalized peritonitis were accompanied by chills occurring in some instances at the onset of appendicitis, in others with the beginning of the symptoms of peritonitis. A limited number of the cases associated with circumscribed abscess gave a history of chills, sometimes occurring at the onset or again after the third or fourth day. Repeated chills occurring late in the course of the malady generally indicate a dissemination of a pyæmic process." Binnie⁷ states, "chills are occasionally present in early appendicitis and usually indicate serious damage to the appendix. Repeated chills are strongly indicative of the infection of new areas or of pyæmia."

TABLE I.
Classification of Acute Appendicitis and Mortality Percentages.

	Number	Mortality per cent.
Total number of cases of acute appendicitis (1916-1925)	2841	5.2
Total number of cases of acute catarrhal appendicitis	842	.95
Total number of cases of acute gangrenous appendicitis	975	3.1
Total number of cases of acute appendicitis with abscess	665	5.4
Total number of cases of acute appendicitis with general peritonitis ..	359	20.0

Quoting from *Osler's Modern Medicine*,⁸ "Chills are sometimes met with at the onset and at various times throughout the course. A considerable proportion of cases begin with rigors and a sense of general coldness after which nausea and other symptoms set in. The chills usually cease after the disease is fairly established and there is no tendency to recurrence until extension of the infected process has caused invasion of the peritoneum. In peri-appendicular abscess regularly or irregularly recurrent chills may continue for a long time. Still more marked is the tendency to chills accompanying widespread infection and in instances of pylephlebitis."

Several of these statements are obviously contradictory. In order to ascertain the occurrence and significance of chills, the histories of 2841 cases of acute appendicitis entering the wards of the Mt. Sinai Hospital, New York, from 1916 to 1925 inclusive, were reviewed. Of these, 836, 29 per cent., were classified as acute catarrhal inflammation; 976, 34 per cent., were grouped in the gangrenous variety; 670, 23 per cent., were complicated by abscess formation, and 359, 13 per cent., were acute appendicitis with general peritonitis. The mortality of this series was 5.2 per cent.; a mortality of 0.95 per cent. in acute appendicitis, 3.1 per cent. in gangrenous appendicitis, 5.4 per cent. in acute appendicitis with abscess, and 20 per cent. for appendicitis with general peritonitis. (TABLE I.)

The exact physiological mechanism of a chill is still obscure. It is known to occur at the onset of certain acute infectious diseases and apparently bears some relationship to venous thromboses. It is not definitely proven that an acute appendicitis can be placed in this latter category, although it probably

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can. In this series, 192 patients gave a history of having had a real, shaking chill, and 206 complained of chilly sensations. In other words, chill, as a clinical symptom before operation occurred in about 6.8 per cent. of all cases.

It is extremely interesting to note that cases of acute catarrhal appendicitis developed a chill in 6.6 per cent. of their number; those with frank gangrene in 6.7 per cent.; those with peritoneal abscess in 6.7 per cent., and those with a general diffuse peritonitis in 6.9 per cent. (Table II.)

TABLE II.
Incidence of Chills and Mortality Percentage.

	Number	Per cent.	Mortality per cent.
Total number of cases of acute appendicitis with chills.....	192	6.8	6.8
Total number of cases of acute catarrhal appendicitis with chills.....	50	6.6	2.
Total number of cases of acute gangrenous appendicitis with chills.....	67	6.7	9.1
Total number of cases of acute appendicitis with abscess with chills.....	50	6.7	6.1
Total number of cases of acute appendicitis with peritonitis with chills.....	25	6.9	8.

From these figures it appears that chills occur in about the same proportion regardless of the pathology at the time of operation. In other words, the degree and extent of the gross pathology seems to have little influence or to bear any relationship to the occurrence of chills within the first forty-eight hours, and as a rule this symptom is not an index of the severity of the disease, or the extent of the pathological process. It seems reasonable to suppose that the mechanism underlying this phenomenon is associated with tissue changes occurring early in the course of an acute appendicitis. This is further attested by the fact that 74 per cent. of the cases of acute appendicitis, 54 per cent. of the gangrenous appendices, 51 per cent. of the cases of

TABLE III (a).
Time of Occurrence of Chill.

Diagnosis	Hours				
	1-12	13-24	25-48	49 or later	Not stated
Acute catarrhal appendicitis.....	74%	18%	6%	0	2%
	92%				
Acute gangrenous appendicitis.....	54%	22%	15%	1%	8%
	76%				
Acute appendicitis with abscess.....	51%	16%	10%	18%	5%
	67%				
Acute appendicitis with general peritonitis.....	55%	15%	8%	10%	12%
	70%				

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abscess and 55 per cent. of those with general peritonitis had their chill within the first twelve hours after the onset of symptoms. Seventy per cent. of all rigors occurred within the first twenty-four hours. (Table IIIa.) A primary chill on the third day, or even later in the course of the disease, seemed

TABLE III (b).
Time of Operation.

Diagnosis	Hours				
	1-12	13-24	25-48	49-72	73 or later
Acute catarrhal appendicitis	48%		30%	10%	12%
Acute gangrenous appendicitis	41%		15%	15%	25%
Acute appendicitis with abscess	20%		24%	15%	31%
Acute appendicitis with general peritonitis	20%		44%	4%	32%

associated with abscess formation, and the delayed occurrence occasionally heralded the onset of a general peritonitis. (Table IIIa.)

Whether the incidence of chills alters the prognosis, or whether cases presenting them are more liable to post-operative complications, especially pylephlebitis, are two very interesting and important problems. The combined mortality of cases with chills was 6 per cent.; the death rate of those without was 5.1 per cent. At first glance, it appears that chills increase mortality figures only slightly. On closer analysis, however, the association of chills with certain types of pathological lesions appears to possess special significance. This is truest in cases of gangrene of the appendix with chills, in which the mortality apparently increases from 2.6 per cent. to 9 per

TABLE IV.
Cases Without Chills and Mortality Percentage.

	Number	Mortality per cent.
Total number of cases of acute appendicitis without chills	2649	5.1
Total number of cases of acute catarrhal appendicitis without chills	786	.18
Total number of cases of acute gangrenous appendicitis without chills	909	2.6
Total number of cases of acute appendicitis with abscess without chills	620	5.3
Total number of cases of acute appendicitis with peritonitis without chills	334	21.

cent. (Tables II and IV.) The cause of death in four of these six patients was attributable directly to pylephlebitis.

Pylephlebitis, in the minds of most surgeons, seems to have been relegated to the frequent complications of appendicitis which have occurred in the past. In this series it occurred in nine cases, or .3 per cent. (see Table V), and yet, of those cases which terminated fatally, 6 per cent. succumbed to this com-

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plication. Almost 5 per cent. of cases with chills subsequently developed pylephlebitis, and of these, 88 per cent. gave a history of ante-operative chills. While it must be granted that this untoward complication occurs in an exceedingly small percentage, nevertheless, a complication which directly or indirectly accounts for more than 5 per cent. of deaths is serious. Petren,⁹ in a collected series of 1340 autopsies in acute appendicitis, found liver abscess, a result of suppurative phlebitis, responsible for 5 per cent. of all deaths. Whenever a history of chills is obtained, pylephlebitis as a potential complication should be borne in mind. Thalheimer¹⁰ goes a step further and remarks, "every case of acute appendicitis should be considered as a potential

TABLE V.
Incidents of Pylephlebitis in Cases with Ante-operative Chills.

	Number	Pylephlebitis
Total number of cases of acute catarrhal appendicitis.....	50	1
Total number of cases of acute gangrenous appendicitis.....	67	4
Total number of cases of acute appendicitis with abscess.....	50	2
Total number of cases of acute appendicitis with general peritonitis..	25 *	0

*Two of these cases developed pylephlebitis with post-operative chills.

one of early pylephlebitis, whether there is a history of chills or not. Consequently, the appendix and its neighborhood should always be carefully inspected (at operation) for the presence of small thrombosed veins, so that these can be dealt with." However, there are innumerable cases with marked venous thromboses of the mesentery, in which an uneventful recovery ensues following appendectomy. Besides, Sonnenberg¹¹ believes that most acutely and chronically inflamed appendices have thromboses, and according to Lenhartz,¹² the prompt ablation of the primary bacterial focus, *i.e.*, the appendix, and the ability of the liver to destroy numbers of bacterial emboli are the reasons that portal pylephlebitis is not more common. It does not seem justifiable to excise the thrombosed veins of the ileo-cæcal angle, as advised by Wilms,¹³ as a prophylactic measure to prevent pylephlebitis. Experience has shown that not only is it almost impossible to excise this entire network, but also that this procedure is dangerous. Sprengel¹⁴ reported a case in which following this procedure, a cæcal fecal fistula developed which autopsy proved to be due to insufficient blood supply.

In 181 cases, in which a single chill was recorded, seven died (two from pylephlebitis), a mortality of 3.7 per cent. In other words, the mortality of cases with a single ante-operative chill was no higher than that for all cases without chill. It is more than likely that the death rate would have been greater had this radical procedure of incision or excision of the thrombosed veins of the ileo-cæcal angle been performed routinely. If there is definite evidence of suppuration in the mesenteric radicles, or the ileo-colic vein is felt as a thrombosed cord, some procedure is certainly justified to prevent the spread of venous infection.

In eleven cases in which chills were multiple before operation, five died,

four of these from pylephlebitis. Pylephlebitis in patients with multiple chills is almost a foregone conclusion; and certainly in those cases a ligation, or resection of the ileo-colic vein, if thrombosed, as advocated by Braun,¹⁵ should be done always as a routine procedure, preferably before the actual appendectomy. A detailed study of the treatment of pylephlebitis of appendicular origin has been considered more fully in a recent communication.¹⁶

The occurrence of post-operative chills, especially when none have been noted before, is extremely rare. In this series of 2841 cases, it happened only three times. Two of these developed fatal suppurative phlebitis of the portal vein and in one there was no explanation for the single chill which occurred.

CONCLUSIONS

1. A history of chills should be inquired from all patients suffering from acute appendicitis.
2. The presence of a chill in the first forty-eight hours is no index of the severity of the disease nor the extent of its pathology.
3. A primary chill on the third day or later, seems associated with abscess formation or the onset of a general peritonitis.
4. When a chill is present, especially in gangrenous appendicitis, the possibility of pylephlebitis should constantly be borne in mind and the appendicular mesentery should be carefully investigated for evidence of suppurative phlebitis.
5. When chills are multiple a routine ligation or resection of the ileo-colic vein should be done, preferably before the actual appendectomy.
6. Post-operative chills are invariably due to suppurative pylephlebitis.

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REFERENCES

- ¹ Deaver and Magoun: *ANNALS OF SURGERY*, 1924, June, vol. lxxix, p. 854.
- ² Gatch and Durman: *ANNALS OF SURGERY*, 1924, June, vol. lxxix, p. 862.
- ³ Gerster: *Trans. of the American Surgical Assn.*, 1903.
- ⁴ Deaver: *Appendicitis*, 3rd Ed., Blakiston, 1905.
- ⁵ Fowler: *Appendicitis*, 2nd Ed., Phil., Lippincott, 1900, p. 54.
- ⁶ Kelly and Hurdon: *Vermiform Appendix and its Diseases*, Phil., Saunders and Co., 1905.
- ⁷ Binnie: *Ochsner Surgical Diagnosis and Treatment*, Phil., Lea and Febiger, 1921, vol. xix, p. 719.
- ⁸ Osler's *Modern Medicine*: Lea and Febiger, vol. iii, p. 309.
- ⁹ Petren: *Bruns. Beiträge*, 1914, Bd. xciv, Heft. 2, S. 314.
- ¹⁰ Thalheimer: *Arch. of Surg.*, March, 1924, vol. viii, p. 658.
- ¹¹ Sonnenberg: *Pathologie and Therapie der Perityphlitis*, Leipsig, 7 Heft., 1913.
- ¹² Lenhartz: *H. Nothnagel, Specielle Pathologie und Therapie*, Bd. iii, S. 366.
- ¹³ Wilms: *Zentralblatt für Chir.*, 1909, Bd. xxxvi, S. 1041.
- ¹⁴ Sprengel: *Zentralblatt für Chir.*, 1911, No. 2.
- ¹⁵ Braun: *Bruns Beiträge*, 1913, Bd. lxxxvi, Heft. 2, S. 314.
- ¹⁶ Colp: *Surg., Gyn. and Obst.*, Nov., 1926, vol. lxiii, No. 5.

TRAUMATIC APPENDICITIS

By RICHARD J. BEHAN, M.D.

OF PITTSBURGH, PA.

MOOREHEAD, in his book on "Traumatic Surgery," states: "It seems highly improbable that any sort of violence could produce a lesion of such deep-seated, movable and well-protected tiny piece of intestine as is the appendix, and yet do no damage to surrounding intestine nearer the source of violence and far more vulnerable."

In view of this statement let us first consider the anatomic fact; that the appendix is not always as freely movable as Doctor Moorehead would have us believe. Very frequently it is changed by past diseases so that either the walls are sclerosed by a prior inflammation or an inflammatory process had spread into the meso-appendix, so that it became thick and unyielding. As a consequence of this thickening the free border of the meso-appendix is shortened and the appendix is curved on itself or is slightly angulated, so that in the latter instance, when the intra-lumenary pressure in the appendix is increased, the mucosa is stretched and a tear may occur with extravasation of some of the intestinal contents (fæces with associated bacteria) into the submucous layer and there is produced either a progressive and active or a slumbering inflammation.

The intra-lumenary appendicular pressure may be increased by any force which decreases the intra-abdominal space. This force, however, must be suddenly exerted, for instance, a squeeze of the abdomen not severe enough to bring about a rupture of a viscus or a sudden blow upon the abdomen (the blow not necessarily being over the area of the appendix). The force must be of sufficient violence to produce a rupture of the mucosa with resulting infiltration and inflammation. If the blow is over the appendix and the abdominal muscles are caught in a state of relaxation, even a bruising of the appendix might possibly occur. However, what most likely takes place is that by the blow, the abdominal muscles are thrown into a state of violent contraction and press forcibly upon the intestinal viscera.

If the colon and cæcum are filled with fecal matter or with gas, the lumen of the appendix is forced open and some of the contents of the cæcum are pushed in. If there is a constriction of the lumen of the appendix, the mucosa is torn and if in addition an enterolith is present, the rebound of the fecal mass from the increased intra-lumenary pressure may close the opening entirely. An accumulation of fluid occurs in the lumen. The increase of the intra-lumenary pressure causes pressure on the veins, so that congestion and cedema of the walls of the appendix follow. The follicles and crypts are opened. There may be minute traumatism (Zwalenburg, p. 443).

If the obstructed lumen of the appendix is now forced open, the inflammation recedes. Should the obstruction be continued, the inflammation

becomes more and more violent and distention, gangrene and perforation of the appendix results. If the lumen contains no concretions and is not constricted, then when the appendix is suddenly distended by gas forced into its lumen from the cæcum the appendiceal valve is stretched and the appendix is suddenly straightened out and rupture of the mucosa is produced; as a rule, either at the base or near to the tip. On examination of such an appendix it is frequently found that the mucosa lies more or less free in the lumen; the pus has apparently dissected it free from the muscularis. If the process is very advanced the mucosa may be entirely destroyed and the appendix becomes totally gangrenous.

However, if the progress has advanced gradually, the inflammatory area surrounding the appendix may be walled off and a localized abscess results. If, however, the course of the disease is rapid and no peri-appendicular adhesions have taken place, there is a sudden and stormy appendicitis.

Traumatic appendicitis may also be the result of injury to the appendix mucosa by foreign bodies, such as pins, seeds, grapes or enteroliths. Injury to the mucosa of itself is not dangerous as long as there is no obstruction of the lumen, which of itself is a potent cause of appendicitis, and it is the most important cause of the disease. Obstruction by kinks, twists, block the circulation and may produce gangrene.

If a sudden contraction, either of the musculature of the cæcum, or of the abdominal wall such as a protective contraction against a blow, or if the abdomen is squeezed, intestinal contents may be pressed into the appendix and the lumen will be dilated. If an enterolith or foreign body is present in the appendiceal lumen, it may be forced into the narrow communicating opening between the appendix and the cæcum and thus close the opening with somewhat the same action as a ball valve and so obstruction results.

Traumatic appendicitis is more apt to occur in those patients who have a thin abdominal wall in which there is either a lack of fatty tissues or a deficiency of muscular tone (weakness of the muscles or defective development). If, as Warbasse says, a blow on the abdomen can cause injury to the bowel, why can it not cause an injury to the appendix?

Traumatic appendicitis may be of special significance in a medico-legal way. If such a pathological entity is generally accepted, there will be a great increase in the number of suits following upon and induced by an accident. If appendicitis is claimed to be the result of an accident, there should be good corroborative evidence that there has been a more or less continuous train of symptoms from the date of the accident to the time of the acute appendiceal attack. These symptoms should be associated and accompanied by intra-abdominal pain from the time of the trauma to that of the onset of the acute appendiceal attack. This pain is not necessarily in the area of the abdomen where the trauma was received.

If an appendix which is kinked by adhesions is suddenly straightened, there is probably some reflex change which normally is interpreted as pain,

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but which is shunted out of consciousness by the more immediate and greater local pain caused by the trauma.

In traumatic appendicitis vomiting is very frequent. It may occur shortly after the trauma and is a sign of intra-abdominal shock. If it persists, it is an indication of acute peritoneal irritation, such as may result from the rupture of a viscus. However, I have never seen a case in which the vomiting came on and persisted without an intermission between the primary vomiting due to reflex intra-abdominal trauma and the secondary vomiting due to peritoneal inflammatory change. The pulse may go up rapidly for a short time, then it returns to, or almost to, normal, and may remain low until the inflammation has progressed to the point where the appendix ruptures. During all this time there is vague uneasy feeling in the abdomen and on sudden or severe exertion the patient may have pain. During this time also the patient complains of pain on palpation and the pain is localized to the appendiceal area. There may also be mapped out in some cases a dulness over the side of the appendix and the rectus is rigid over this area. After peritonitis has begun there is, of course, a marked rigidity and great tenderness. Tympany may not be excessive, though later when paralysis of the bowel occurs, it is most marked. The symptoms are now those of acute appendicitis.

If the appendix ruptures there is a sudden change. The pulse becomes very rapid and the temperature which has been normal or slightly above normal becomes very high and the patient presents a very sick appearance, for he has a peritonitis which is rapidly becoming generalized. Another symptom group immediately intrudes, namely, the symptom group of ileus. Vomiting becomes persistent and the patient rapidly passes into a state of extreme toxæmia.

Treatment.—Appendicitis, wherever and whenever it occurs, if the surroundings are suitable, should always be operated, using the regulation technic. If rupture and peritonitis is present, drainage with a provision for enterostomy should be made. Care must be taken that interference of too severe a character is not undertaken.

In one of my cases, there is no doubt of the relationship between trauma and the resulting appendicitis with resulting peritonitis. In a second case the sequence is not as definite.

The history of the first patient is as follows:

H. R., American, shipping clerk, twenty-eight years old, on entering the hospital complained of pain in the abdomen diffuse in character, nausea, weakness and general malaise. The onset was sudden. On September 9, 1917, Sunday morning after breakfast, the patient was seized suddenly with severe cramps in the lower abdomen. The pain gradually increased in severity. He says he did not vomit but felt weak. That same evening the patient went out to look for a doctor, found one, who gave him electric treatments. That night the patient was very restless, unable to sleep, fussed the whole night. Monday morning, September 10, 1917, the family physician was called. Medications were given. No relief all day Monday; the patient felt miserable. Tuesday morning the patient became worse. The same physician was called in in the afternoon in consultation with another doctor and the parents were advised to rush their son to the hospital. Tuesday night patient entered the hospital.

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The patient dates his illness to three weeks ago, when he fell over a tomato patch, landing on a sewer crock, inflicting a bruise on the left side of the abdomen. From this time he had severe pains in the abdomen which were more or less constant. After the first severe onset the tendency was for the pain to be localized in the right side. During this entire time the right lower iliac fossa was very tender to the touch.

The past, personal and family history is negative.

Examination by Doctor Behan on evening of entrance to the hospital.—Patient is apathetic. Tongue slightly coated and moist. Chest, right side, dullness lower lobe; vocal resonance increased; breath sound diminished. Left side negative. Heart negative; abdomen distended; very sensitive to touch. Respiration movement of the abdomen is absent. On palpation resistance is increased probably more on the right than on the left side. The patient is tender over the entire abdomen. The slightest touch causes severe pain; deep pressure is not so painful. The patient localizes his greatest tenderness to the abdomen below the umbilicus. When told to localize it with one hand, he indicated the right iliac fossa. Dullness is present in the right iliac fossa. Peristalsis is not marked, but is present on both sides. The small waves are most numerous on the left side—the large waves also. On the right side the small waves are entirely absent. Hyperalgesic areas are not well defined. Pulse, 120. Blood examination showed white blood-cells, 17,400; polymorphonuclears, 84 per cent.; lymphocytes, 16 per cent. Blood-pressure, 88 over 58.

Diagnosis.—Generalized suppurating peritonitis primary from the appendix.

Operation.—10.45 P.M., September 11, 1917.—Spinal anaesthesia—tropococaine one amp. and local anaesthesia novocaine one-half per cent., 75 c.c. Right rectus incision. The peritoneum was thickened. On opening the peritoneum a considerable quantity of dark, foul liquid exuded. The drainage apparatus was connected and about 400 c.c. of the fluid was collected in the aspirating flask. The intestines were dark in color and considerably distended. The caecum was bound down to the lateral peritoneal wall and around it were fibrin deposits. An attempt was made to separate the adhesions, but because of their resistance was not persisted. A tube was inserted down into the pelvis. A cigarette drain through a counter opening in the lowest part of the right lower iliac region. Gauze drains were inserted through the operative incision down to the appendix area. The wound was closed. On the left side in the iliac area another opening was made under local anaesthesia into the abdomen. The muscles being split, the same character of fluid was found on opening the abdomen. A cigarette drain was inserted in the direction of the pelvis. About one ounce of foul liquid was obtained by suction. Wound was partially closed. Operating time—about one hour and twenty-five minutes from beginning of injection to the end of operation. Patient left the table in fair condition. Pulse 135. He had hypodermoclysis submammary of 500 c.c. of sodium bicarbonate 2 per cent. and glucose 5 per cent.

September 13, 1917.—Blood-pressure was 108 over 65. Patient was dressed. The dressings were saturated. Patient complains when pulling is made on the drains. Abdomen is not distended. Tongue is dry. The patient talks rationally. General condition much improved during the past twenty-four hours. Last night a great deal of distention. At 1.30 A.M. the stomach tube was used. Gas of a foul odor was evacuated. Later the abdomen was distended. The rectal tube was ordered and the condition was relieved.

September 17, 1917.—Patient has been restless all night; slept about three and one-half hours off and on. Complains a great deal and wants his bed changed to a Fowler's position. Tongue is still dry. Lips very dry and scaly and fissured. Incision clean. Two iodoform gauze drains. One gauze drain reinserted for drainage. Otherwise clean and very little discharge. Abdomen still somewhat distended.

September 18, 1917.—Patient has been dressed this morning. Very little discharge present. Drains inserted. Opening drawn together with adhesive plaster. Abdomen greatly distended. Enema ordered; eyes brighter; color better. General condition improved.

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October 3, 1917.—Wound looked good. Right side almost healed. Left side entirely healed. Abdomen flat. Patient discharged.

One year later. Patient still in good health, although he complains at times of pulling and dragging in the abdomen.

Reports of Cases from Literature.—Borchardt-Moritz (Die Behandlung der Appendicitis mit aus dem Grenzgebieten der Medizin und Chirurgie, Bd. xi, p. 305) found three cases of traumatism in 150 cases of appendicitis.

SCHOTTMULLER reports two cases of children receiving severe blows on the abdomen with immediate signs of peritoneal injury, which later proved to be due to appendicitis.

Schottmuller explains the course of the appendicular inflammatory process as follows:

1. Fecal concretion is present in the lumen.
2. Through pressure at the point where the stone lodges a necrosis and ulceration of the inner wall of the appendix results. This is not dangerous and produces no symptoms. However, if now there is a sudden trauma, the thin-intact outer wall is torn or will be destroyed. The infectious contents are now forced out into the free peritoneal cavity and peritonitis results. The sudden rupture and the overwhelming of the peritoneal cavity by the infection explains why in these cases we have no adhesions.

BLOCK, in the *Denver Medical Times*, states that out of 129 cases of appendicitis, traumatism was quite positive in three cases. The first case fell; symptoms with severe abdominal pain; developed six hours after falling from a bicycle. The second case was kicked by a pony; over and just to right of umbilicus. Pain severe in abdomen, most marked over gastric region. Third case, lifting heavy furniture; four hours later severe pain in right side of abdomen.

SMALL reasons that trauma is instrumental in causing the increase in appendicitis over former years. He says that 75 per cent. to 80 per cent. in young adults, of appendicitis, is caused from trauma. Seventy-five per cent. are under thirty years of age. He cites the case of a boy nine years old who had pain come on while he was pushing a heavy cart; the tongue of the cart was pressing against his abdomen. On operation, five days later, pus was found in the abdomen. The appendix had sloughed away.

SOUTHAM, in the *Lancet*, reports four cases of traumatic appendicitis. He believes that severe strain may cause sudden and forcible contraction of the abdominal muscles and so separate or break down adhesions between the appendix and the abdominal wall and cause an extravasation of blood, either into or around the appendix.

In one case, in a boy nine years of age, there was no history of any previous pain. He had been struck on the abdomen. There was pain in the right iliac area. The next day he was confined to bed. He vomited constantly; on the fourth day temperature was 100, pulse 120. Operation, appendix inflamed, almost perforated in one spot. Contained a concretion. Numerous recent adhesions around the appendix. Pus was diffused throughout the peritoneal cavity.

In cases of traumatic appendicitis it is usually claimed that the pain generally comes on immediately after the trauma and is frequently though not absolutely localized to the right side. In three out of the four cases of Southam, it was not at first localized, but gradually became so.

LADUSKI reports one case of a boy, eleven and one-half years, who had some slight cramps in the abdomen prior to a fall on the abdomen while sliding down a banister. Immediately after the fall he had pain in abdomen, nausea and vomiting. On operation the abdomen was found filled with blood and a rent of about one and one-half inches was present at the end of the meso-appendix. In this there were several small bleeding vessels. The patient recovered.

WARBASSE, *New York Medical Journal*, vol. iii, No. 8, pp. 411-413, believes that as a rule there is some pain present in the abdomen at the time of the traumatism. This

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may entirely disappear and no unusual symptoms be present for one or two days; then the pain recurs in the right side and a well-defined appendicitis becomes evident.

DEAVER says that in a previously healthy appendix, he has never seen appendicitis produced by a blow or traumatism.

WARBASSE further states that traumatism may be due to the following:

1. Abrasion of mucosa by foreign matter.
2. Lowering of the vitality of the mucous membrane cells by retained secretions.
3. Distention of follicles by retained bacteriological products.
4. Presence of an excess of ptomaines retained in the appendix against the pressure of the contents of a distended cæcum. If traumatism can cause injury to the bowel, why not, as Warbasse says, cannot it cause injury to the appendix?

SAVAGE, in *Medical Record*, reports a case, sixty-one days old, where the appendix and colon were down in a scrotal right inguinal hernia. For one week efforts at reduction by taxis were made. Operated; caput-coli in sac; appendix inflamed and perforated. Death in two days.

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REPORT OF ADDITIONAL CASES

BY WILLIAM JAMES CARSON, M.D.

OF MILWAUKEE, WIS.

FROM THE DEPARTMENT OF PATHOLOGY, UNIVERSITY OF MARYLAND

OWING to the number of different names under which the lesion has been described as "membranous," "pseudomembranous," "croupous," "diphtheritic," "exfoliation," "plastic," and "gangrenous cystitis," which are misleading, it is impossible to state the exact number that have shown necrosis with putrefactive changes. Wolferth and Miller found 9 gangrenous and 12 of necrosis in the 21 cases which they reported.

Willis,¹ in 1650, was the first to describe necrosis of the urinary bladder; Tulpius,² in 1716, and Fontaine,³ in 1815, without microscopical examination of the bladder. Bauer,⁴ in 1853, reported a case which was studied microscopically by Lusk.⁵

The first cases to be reported with accurate histological examinations were by Lever,⁶ 1853, and Lee,⁷ 1863. Dolbeau,⁸ in 1864, reported a case which occurred with calculi in the bladder. May,⁹ in 1869, and Heubner,¹⁰ in 1883, produced necrosis of the bladder experimentally on rabbits and dogs.

Guyon¹¹ described fully two types: First, the false and pseudomembranous type, which may be called diphtheritic, where the membrane is a fibropurulent exudate, and, second, necrosis of the bladder.

Haultain,¹² in 1890, reported 2 cases and collected 54 cases from the literature.

In 1910, O'Neill¹³ reported 2 cases and collected 50 additional cases from the literature not included in Haultain's report, making 108 reported cases of necrosis or gangrene of the bladder.

Wolferth and Miller,¹⁵ in 1924, reviewed the literature and added 19 cases of their own, making a total of 153 cases of necrosis and gangrene of the urinary bladder.

Pausson,¹⁸ in 1894, reported 17 cases of extroversion of bladder through the urethra which he observed to the end, 6 deaths were due to gangrene of the bladder, and urinary infection (not included in reports 13, 14 and 19).

Since my first communication on this subject,¹⁹ Eliason²⁰ has reported a case of spontaneous rupture of gangrenous urinary bladder occurring in a woman, age thirty, diagnosed as appendicitis. The gangrenous area was excised and the patient recovered.

Costantini, Bernasconi and Duloucher²¹ reported 2 cases: (1) A male, age fifty-five years, died with gangrene of the bladder following an operation for prostatic abscess. (2) Female, age forty-two years, with a history of three pregnancies, lues, and retention of urine four years previous to entering

* Read before the Wisconsin Urological Society, Madison, October 29, 1926.

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hospital with hæmaturia, retention of urine and urethral discharge. Cystoscopic examination showed 1200 c.c. residual urine with gangrene of the bladder. Treated by Dakin solution, irrigations, recovered.

To the above 167 cases, I wish to add 6 cases which occurred on the autopsy service at the University of Maryland since July, 1924, making a total of 173 cases of gangrene of the urinary bladder.

CASE 168.—Colored, female, age thirty-five years, admitted to the University Hospital, March 14, 1925, from the outside obstetrical service after having been in labor twenty-

four hours with a clinical diagnosis of abruptic placenta, a still-born child was delivered by version and breach extraction. The general condition of the patient was fairly good for the next few hours, but after this her condition grew steadily worse until she died March 17, 1925, with a clinical diagnosis of abruptic placenta; undetermined hemorrhagic condition in stomach, bladder and lower intestines.

Autopsy No. 1119.—Bladder.—Muscular wall is thickened (6 to 8 mm.) with the mucosa of the trigon and base of a greenish-black color. A putrid odor is present. On the fundus a yellowish exudate is found in areas. Ureteral orifices are scarcely visible.

Anatomical Diagnosis.—Gangrenous endometritis with perforation of the lower anterior wall of the uterus into the peritoneal cavity; hemor-

rhage into peritoneal cavity; acute generalized peritonitis, gangrenous; acute gangrenous cystitis; acute phlegmonous gastritis; acute enterocolitis; acute diffuse nephritis; hydro-ureter, bilateral¹⁰; hydronephrosis, bilateral; pyelitis, bilateral.

CASE 169.—Colored, female, age twenty-five years, admitted to University Hospital, July 20, 1925, with a clinical diagnosis of chronic salpingitis with tubo-ovarian abscess; lues. Her condition gradually improved until August 14, 1925, at which time a supravaginal hysterectomy and bilateral salpingo-oophorectomy were performed by Dr. J. M. Hundley, Jr. An adherent mass was found to consist of adherent intestine, great omentum, tubes and ovaries, adhesions were freed with great difficulty and some bleeding. The mass was also adherent to the fundus of the bladder, and on relieving these adhesions, two small perforations were made in the fundus of the bladder, which were closed by No. 1 plain catgut.

Autopsy No. 1147.—August 21, 1925. *Bladder.*—On the fundus there is an opening measuring 1 cm. in diameter, with catgut sutures adherent to its edges. In the left



FIG. 1.—Case 171. Autopsy No. 1158. Gangrenous cystitis following suprapubic prostatectomy, ureteral dilatation, bilateral (adenocarcinoma of prostate).

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posterior margin of the fundus a second opening 1 cm. in diameter is seen, with catgut sutures adhering to its edges. The muscular wall varies from 5 to 9 mm. in thickness. Mucosa is covered by a yellowish exudate in several areas. Upon removing the exudate, the mucosa is of a reddish-green color; just above the trigon and surrounding the perforations it is of a greenish-black color. Urethra shows the mucosa to be of a bright reddish color, with some exudate adherent to it.

Anatomical Diagnosis.—Acute gangrenous peritonitis, pelvic portion; acute generalized peritonitis, upper half; subhepatic abscess; subdiaphragmatic abscess; gangrene of the bladder, cæcum, and sigmoid; with perforation in bladder and sigmoid; acute diffuse nephritis, bilateral; pyelitis, bilateral; ureteritis, bilateral.

CASE 170.—Colored, male, age sixty-three years, admitted to University Hospital, September 29, 1925, service of Dr. W. H. Taulson, for acute retention; uræmia; multiple calcified strictures of the urethra; chronic purulent cystitis; inguinal hernia; left; terminal broncho-pneumonia. Under local anæsthesia a suprapubic cystotomy was performed. Patient died September 30, 1925.

Autopsy No. 1151.—Prostatic urethra is moderately dilated. The veru is of a dark red color, with a purulent exudate exuding from the ejaculatory ducts. Membranous urethra is markedly dilated, with a large calculus in this dilated membranous urethra 3.5 by 2.5 cm. At the proximal portion of the pendulous urethra a band of scar tissue is seen surrounding the urethra. Anterior to this stricture the urethra shows small areas of a dark red color, and an exudate can be pressed out of the glands of Littre.

Bladder.—The muscular wall is markedly thickened, measuring from 8 to 12 mm. in thickness, with a rubber catheter in the fundus of the bladder. Mucosa is of a dark greenish-black color throughout with a putrid odor present. The trigon is reddish-green in color. Urethral orifices gaping.

Anatomical Diagnosis.—Stricture of urethra junction of anterior and membranous; dilatation of membranous urethra; large calculus in membranous urethra; chronic prostatitis; gangrenous cystitis, localized; ureteritis, bilateral; pyelitis, bilateral; hypertrophy of the bladder; chronic epididymitis, left; with abscess formation. Chronic diffuse nephritis with acute diffuse nephritis.



FIG. 2.—Case 173. Autopsy No. 1190. Gangrenous cystitis extending down into prostatic cavity following suprapubic prostatectomy. (Adenoma of prostate.)

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CASE 171.—White, male, age sixty-two years, admitted to the University Hospital, July 21, 1925, service of Dr. W. H. Toulson, with a diagnosis of carcinoma of the prostate. August 26, 1925, a suprapubic cystotomy was performed under local anesthesia. November 5, 1925, suprapubic prostatectomy. Patient died in uræmic coma, November 7, 1925.

Autopsy No. 1158.—Bladder.—There is an opening in the fundus 1 cm. in diameter with a rubber tube extending into the bladder. On the lateral wall there is an area 3 by 4 cm. which is of a dark blackish-green color with a putrid odor present. Trigon is of a dark red color with the ureteral orifices visible. Vesical orifice shows numerous tags. In the prostatic urethra a portion of the prostate is adherent to the prostatic capsule.

Anatomical Diagnosis.—Adenocarcinoma of the prostate with metastasis to the lymph-nodes along the internal iliac arteries, abdominal aorta, renal arteries, and liver; hydro-ureter, bilateral; hydronephrosis, right; gangrenous cystitis, chronic diffuse nephritis; acute diffuse nephritis.

CASE 172.—Colored, male, age fifty-five years. Admitted to the University Hospital, November 18, 1925. Service of Dr. W. H. Toulson.

Clinical Diagnosis.—Acute retention of urine, hypertrophy of the prostate.

Operative Note.—November 18, 1925, suprapubic cystotomy under local anesthesia. December 7, 1925, suprapubic prostatectomy. The peritoneum was accidentally opened. Prostate—each lobe measured 5 cm. in diameter when removed. Microscopical diagnosis—adenoma of prostate.

Autopsy No. 1165.—December 20, 1925. *Bladder.*—There is a recent operation wound in the fundus. The muscular wall is markedly thickened, varying from 2 to 3 cm. in thickness. The peritoneal surface is smooth and glistening. The muscular wall shows the line markings to be indistinct in outline in the fundus. The base and lower 3 cm. of lateral wall is of a greenish-black color, with a putrid odor present, in this region no line markings are visible. Mucosa—the base and lateral walls are of a greenish-black color with yellowish necrotic material on its surface in areas. Ureteral orifices scarcely visible; at the fundus the mucosa is of a dark red color. Just above the left ureteral orifice a diverticulum 2 cm. in diameter is seen.

Anatomical Diagnosis.—Recent operation wound—suprapubic; abscess of prostatic gland; acute gangrenous cystitis; ureteritis; bilateral; pyelonephritis with abscess formation, bilateral; hydro-ureter, right; adhesions between coil of ileum and operation wound; adenoma of adrenal, right.²³

CASE 173.—Colored, male, age fifty-nine years, admitted to the University Hospital, February 9, 1926, service of Dr. W. H. Toulson. Clinical diagnosis hypertrophy of the prostate; infection of upper urinary tract. February 14, 1926, suprapubic cystotomy. March 15, 1926, suprapubic prostatectomy. Patient died March 31, 1926, from uræmia.

Autopsy No. 1190.—Bladder.—Muscular wall is markedly thickened (2 cm.). In areas it is soft. The mucosa is scarcely visible, most of the bladder being covered with a thick layer of greenish-black necrotic material with yellowish necrotic material in areas. This greenish-black material extends down into the prostatic urethra, the prostate being absent.

Anatomical Diagnosis.—Recent operation wound suprapubic; absence of prostate gland; gangrenous cystitis; hydro-ureters, bilateral; hydronephrosis, bilateral; pyelonephrosis, bilateral; acute diffuse nephritis, etc.

Etiology.—Necrosis or gangrene of the bladder occurs as a result of: 1. Interference with the circulation, internal or external pressure. 2. Infection, general or local, with or without mechanical injury. 3. Lesions of the central nervous system. 4. Chemical irritants.

Incidence.—Gangrene of the urinary bladder occurs more frequently in females—116 females, 57 males (including the six cases of this report). The

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age varies from three years to seventy-five years, with the majority of cases occurring in the third and fourth decades.

Mortality.—In the 173 cases 102 died, 67 recovered, and the outcome is not stated in 4.

Discussion.—In reviewing the 173 cases of gangrene of the urinary bladder, it is seen that 40 cases were associated with retropregnant uteri; 23 occurred after labor—15 of which had retention of urine; 11 were due to external pressure in females with retention in 6 of the 11 cases; cystitis was the antecedent in 14—7 males, 7 females; 7 of the 14 cases of cystitis were complicated by retention, stricture of the male urethra 9 cases, with calculi in the urethra in 3 of the 9 cases, retention 8; prostatic obstruction 6 with retention in each case; calculi in bladder 6, retention 6; irritants 6—2 males, 4 females, retention 1; general infections 15—4 males, 11 females, retention 7; lesions of the central nervous system 12, males 8, females 4, retention 7; trauma 5, males 3, females 2, retention 3; extroversion of bladder through the urethra 6, females; miscellaneous 20, males 11, females 7, retention 10.

Retention of urine was present in 76 of the 173 cases (48.5 per cent.).

Obstruction to the circulation will explain the cases of simple necrosis, but to have putrefaction changes it is necessary to have a pathogenic bacteria present, and from the variety of conditions that have been associated with gangrene of the bladder it is quite evident that infection, primary or secondary, was present.

In the sixty-seven cases that recovered the diagnosis was made by cystoscopic examination, suprapubic cystotomy or examination of the exudate passed per urethram.

CONCLUSIONS

1. One hundred and sixty-seven cases of necrosis and gangrene of the urinary bladder are collected from the literature.

2. Six cases of gangrene of the bladder are reported.

The writer is indebted to Prof. Hugh R. Spencer for the many privileges which he received during his seven years as a member of the pathology staff at the University of Maryland.

BIBLIOGRAPHY

- ¹ Willis: *Dissertatio de Urinis*, 1650.
- ² Tulpus: *Observ. Med. Lugdani Batavorum*, 1716.
- ³ Fontaine: *Catarrhe de la Vessie*, Thesis, Paris, 1815.
- ⁴ Bauer: *Med. Corresp. Bl. d. Wurtemb. arztl. Ver. Stuttgart*, 1853, vol. xxiii.
- ⁵ Laska: *Virchow's Arch.*, 1854, vol. xxx.
- ⁶ Lever: *Guy's Hospital Reports*, 1853, vol. viii, p. 49.
- ⁷ Lee: *Path. Trans.*, London, 1863, vol. xv, p. 136.
- ⁸ Dolbeau: *Tr. Proc. de la Pierre dans la Vessie*, 1864, p. 309.
- ⁹ May: *Inaugural Dissertation*, Glissen, 1869.
- ¹⁰ Heubner: *Die Experimentelle Diphtherie*, Leipsic, 1883.
- ¹¹ Guyon: *Annal des Mal des Org. Genito Urinaires*, July and August, 1887.
- ¹² Haultain, F. W. N.: *Laboratory Reports of Royal College of Physics*, Edinburgh, 1890, vol. ii, p. 216.
- ¹³ O'Neill, R. F.: *Surg., Gynec. and Obstet.*, 1910, vol. x, p. 503.

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- ¹⁴ Miller, T. G., and Wolferth, C. C.: Jour. Amer. Med. Assoc., 1922, vol. lxxix, p. 1756.
- ¹⁵ Miller, T. G., and Wolferth, C. C.: Amer. Jour. Med. Sci., 1924, vol. clxvii, p. 339.
- ¹⁶ Judd, E. S., and Meeker, W. R.: Jour. Urol., 1924, vol. xi, p. 411.
- ¹⁷ Aschner, P. W.: Jour. Urol., 1924, vol. xii, p. 252.
- ¹⁸ Pausson, A.: Inversion de la Vessie et sa Hernie, Annales des Maladies. org. genit-urin., 1894, vol. xii, p. 408.
- ¹⁹ Carson, W. J.: Jour. Urol., 1925, vol. xiii, p. 205.
- ²⁰ Eliason, E. L.: ANNALS OF SURGERY, 1925, vol. lxxxi, p. 546.
- ²¹ Costantini, Bernasconi and Duloucher: Revue De chirurgie, Paris, 1924, vol. cxii, p. 590.
- ²² Spencer, H. R.: Adenoma of the Adrenal, Archives of Pathology and Laboratory Medicine, 1926, vol. ii, p. 691.

LIPOMA OF THE TESTICLE

WITH A CONSIDERATION OF FAT ATTACHED TO THE INGUINAL
AND SCROTAL PERITONEUM

By CLYDE A. ROEDER, M.D.

OF OMAHA, NEB.

GALEN described fatty masses within the scrotum as attached to the spermatic cord and testicle, calling them *steatoceles*. Ambroise Paré also described scrotal lipomata, feeling that they preceded inguinal hernia through the internal inguinal ring and that they were the etiological factor in the descent of the bowel. The works of de Garengot, Morgagni, Paré, Scarpa, Monod and Terrillon, Gage and Fish and the new book on hernia by Watson treat this subject of scrotal and inguinal fat most interestingly. Throughout the literature, fatty masses within the inguinal canal and scrotum have been termed fatty hernias and fatty tumors of the testicle respectively. Fatty inguinal hernias are, in reality, hyperplastic masses of subperitoneal fat attached to the vaginal process of the cord. In the few reports I could find of tumors of the testicle, it was not difficult to decide that in most instances they were examples of hyperplasia of the fat surrounding the lower portion of the spermatic cord, which had projected downward into the scrotum. The case I am reporting can stand as a lipoma originating from the testicle, providing the mesothelial coat of the testicle, the tunica vaginalis viscerum is considered a part of this organ. The true capsule of the testicle, tunica albuginea, perhaps originating from the transversalis fascia, is also an acquired structure, and in order to satisfy the most critical, a true lipoma of the testicle should arise from within the tunica albuginea. Fat within this tunic has been found normally only in the mediastinum testis. Since the lipoma I am reporting arose from the visceral layer of the tunica vaginalis, perhaps I should, to be more exact, report this as an example of: "Hyperplasia of the Subperitoneal Fat beneath the Mesothelial Coat (tunica vaginalis viscerum) of the Testicle."

EMBRYOLOGY

Fat within the inguinal canal is frequently seen during herniotomies, and when occurring as a mass, is generally called a fatty hernia. Fat within the inguinal canal and scrotum should not be looked upon as abnormal and a study of the embryology of the scrotum and inguinal canal, together with their contents, signifies that fat is a normal content.

The scrotum is formed by a constriction of the lower walls of the abdomen. This constricted portion of the lower abdominal wall naturally contains peritoneum which lines the scrotum from the time of its origin; and later when the testicle descends, wraps itself around this organ forming both of its tunics, *i.e.*, vaginalis viscerum and vaginalis parietum. Therefore, the

mesothelial tunics of the testicle and cord, which are nothing more than constricted peritoneum, precede the testicle and cord into the scrotum. In exploring undescended testes the so-called sac is always found extending lower than the testicle, proving its priority *in situ*.

One characteristic of subperitoneal areolar tissue is the favoring of depositions of fat, which is so beautifully shown by the work of Gage and Fish (*American Journal Anat.*, 1924). If the intra-abdominal subperitoneal

tissue favors fat deposits, it is natural to assume that the inguinal and scrotal subperitoneal tissue would also. We see this demonstrated in operating upon inguinal hernias where so frequently we find fat deposited along the cord and connected, through the internal inguinal ring, with the intra-abdominal subperitoneal fat. Therefore, so-called fatty tumors of the testicle, unless proven to arise from the mediastinum testis, perhaps had better be looked upon as hyperplasia of the subperitoneal fat originating from the areolar tissue beneath the tunica vaginalis viscerum, or "the testicular peritoneum."

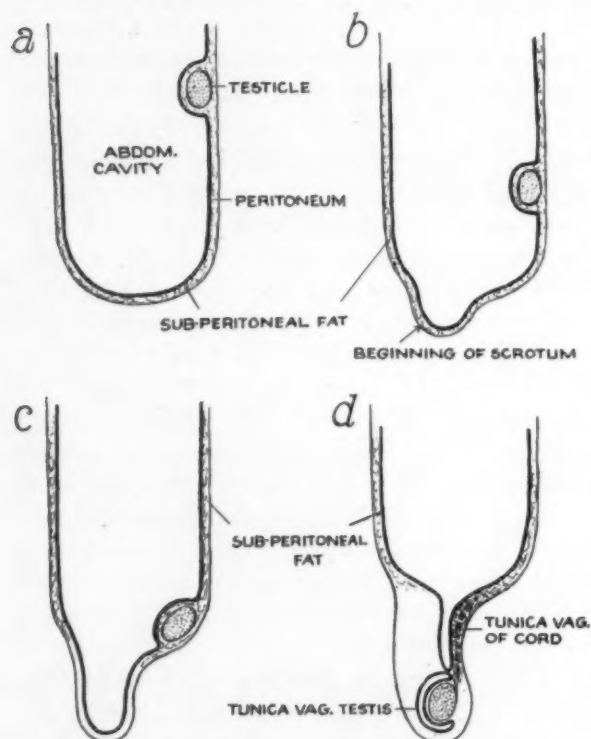


FIG. 1.—Embryological formation of the scrotum, showing the natural tendency of deposition of subperitoneal fat around the testicle and spermatic cord.

Historical.—After a thorough search of the literature in preparation of an article read before the Minnesota State Medical Association in June, 1926, entitled "The Relation of Subperitoneal Fat to Abdominal Hernia," and which took in all reports I could find of fatty growths in the scrotum from the time of Hippocrates, I could find only eight reports of Lipomas of the Testicle, which bore scrutiny. A few other articles, of similar title, when carefully analyzed were easily determined to be tumors originating from the lower portion of the spermatic cord. Monod and Terrillon (*Traite Des Maladies du Testicule et de Ses Annexes*, Paris, 1889, p. 699), in the most complete work up to 1889 on diseases of the testicle and annexed structures, state that the only true case they were able to find was that reported by Roswell Park. After reporting his case, Park cites the cases of De Guise and Jobert as tumors of the testicle. I found, however, that both De Guise

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and Jobert first thought that they each had found a lipoma of the testicle, but upon careful dissection they found in each instance that the tumors had descended from the lower portion of the spermatic cord. Even Park's famous case can be looked upon as more likely originating from the lower spermatic cord than from the testicle. Theodor Kocher reports two cases as lipomata of the testicle, but upon careful study of his articles, I feel that both were undoubtedly lipomata originating from the lower portion of the spermatic cord. J. A. Orr and J. Morgan each report fatty tumors of the testicle; they described them as discharging fungoid masses. In my estimation their reports are indefinite. The case of H. J. De Rooy, I think, is a true fatty tumor of the testicle as well as the case reported by H. A. W. A. H. Grote. It is interesting to note that Karewski reports a case of lipo-sarcoma originating from the tunica vaginalis testes.

CASE REPORTS

I.—AUTHOR'S CASE.—

Patient, fleshy type, age forty-two, past history negative. A left inguinal hernia had been present for twenty years and a hydrocele of the tunica vaginalis testis about 8 cm. in diameter, for eight years. Both hernia and hydrocele were gradually increasing in size and causing more distress. At operation, I found an indirect inguinal hernia with an acquired sac extending down to the testicle. Surrounding the cord and beneath the sac was a continuous and complete layer of fat extending from the testicle up to and through the internal inguinal ring. After the sac of the hydrocele had been cut away as much as possible, a small nodule beneath the testicular layer of the

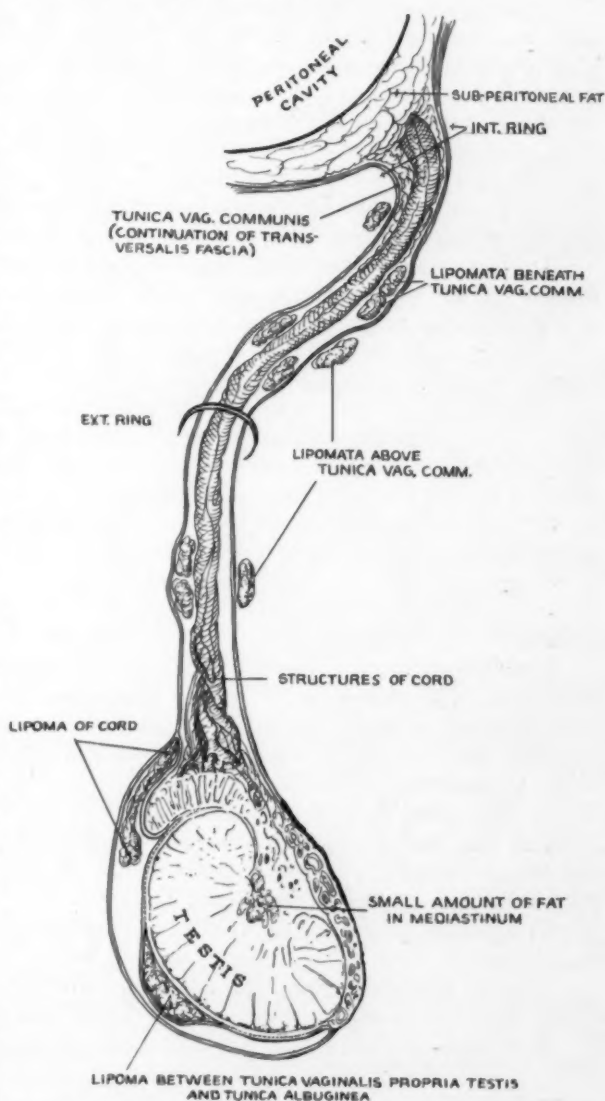


FIG. 2.—Fatty tumor of the testicle which may have arisen from subperitoneal fat deposited beneath the tunica vaginalis viscerum.

tunica vaginalis was noted. An incision showed it to be a fatty nodule well encapsulated and more intimately attached to the tunica vaginalis than to the tunica albuginea. It was so easily determined to be fat that a microscopic section was not made. (Fig. 2.)

II.—DE ROOY, H. J.—*Insigni tunica vaginalis testis degeneratione, aliorumque organorum vitis, in cadavere senis 104 annorum observatis*. Thesis, Lugduno-Batava, 1823.

"During an autopsy on a man 104 years old, a tumor was found in his right scrotum, which was about the size of the head of a new-born infant. The viscera, excepting a slight lobulation of the liver, were in their normal condition. The prostate was enlarged and dense in structure and the seminal vesicles were collapsed. The most conspicuous feature was "the singular degeneration of the tunica vaginalis of the right testicle." The tumor was elastic in some portions and almost bonehard in others, with intervening fluctuating parts; its size was four thumb lengths by three and one-half thumb lengths. The exact location of the testes was not possible. The vasa spermatica, the vas deferens and the epididymis seemed healthy.

The tumor tissue looked crystallized and cold water did not dissolve it. Cold alcohol likewise did not change the crystals, but hot alcohol did. The tumor was made up of adipose substances which by Fourcroy has been called 'Adipocerae (adipocire).'"

III.—GROTE, H. A. W. A. H.—Inaug. Thesis, Gottingen, 1908.

Patient, age thirty, an epileptic. Eight years previously had noticed a pea-size tumor apparently attached to the left testicle. The past two years the tumor had grown to the size of a hen's egg. During the past six months, another tumor had developed close by. At operation, a fatty tumor, the size of a hen's egg, was found with a few attached nodes of fat the size of a bean. It was attached to the testicle for about a pencil's breadth. The epididymis and the testicle were found to be normal. Grossly the tumor was composed entirely of fat and covered by the tunica vaginalis on the sides and back. Microscopically it contained numerous fibro-myomatous nodules which were very cellular and of the fibro-sarcomatous type.

IV.—PARK, ROSWELL. *ANNALS OF SURGERY*, 1886.

Patient, age forty, presented a tumor of the scrotum the size of a foetal head. After removal it weighed three pounds. Park states that he could not determine the exact origin of the tumor, i.e., from the testicle or lower portion of the spermatic cord. He stated that the condition was rare and could find only two other reports of lipomata of the testicle, those of De Guise and Jobert.

V.—DE GUISE. *Ann. Soc. de Chir. Paris*. Ire serie, T9, 529, Juin, 1859.

This case, reported by both Park and De Guise as a fatty tumor of the testicle, was found to be, after a careful dissection by De Guise, a fatty tumor originating from the lower portion of the spermatic cord.

VI.—JOBERT, L. *Mem. Soc. Biol. Paris* ire serie, 2, 78, 1850. *Gazette Med. de Paris*, 1850.

This case, also reported by Park, was found, after careful dissection by Jobert, to be a fatty tumor originating from the lower portion of the spermatic cord.

VII.—KOCHER, TH. *Krank, des Mannlichen Geschlechtsorgane*. *Deut. Chir.*, 1887, p. 183.

From Kocher's own description, he admits that he was unable to determine whether or not the tumors came from the lower cord or testicle.

VIII.—ORR, J. A. *Dublin Medical Press*, 1847, vol. xvii, p. 56.

Reports a case of lipoma of the testicle. Speaks of the tumor as a granular or fungus mass. Description indefinite.

IX.—MORGAN, J. *Dublin Medical Press and Circular*, 1867, vol. iv, p. 546.

Reports a case of fatty tumor of testicle. Describes it as a fungus discharging mass. Case doubtful.

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BIBLIOGRAPHY

- ¹ Callisen: *Systema Chir. Hodiernæ*, 2, Ed. 1827.
- ² Curling: *Treatise Diseases of Testicle*, 1856.
- ³ Curling: Todd and Bowman's *Ency. Anat. and Phys. Disease of Testicle*, 4th Ed., 1878.
- ⁴ De Carengeot, R. J. C.: *Mem. Acad. Roy. de Chir.*, Paris, vol. i, p. 669, 1743.
- ⁵ De Guise: *Ann. Soc. de Chir. Paris. Ire serie*, T9, p. 529, Juin, 1859.
- ⁶ De Rooy, H. J.: *Thesis, Lugduno-Batava*, 1823.
- ⁷ Gage and Fish: *Am. Jour. Anat.*, Sept., 1924.
- ⁸ Galen: Quoted by Curling.
- ⁹ Gascoyen: *Tr. Path. Soc.*, vol. xvii, 1867.
- ¹⁰ Grote, H. A. W. A. H.: *Inaug. Thesis*, Gottingen, 1908.
- ¹¹ Jobert, L.: *Mem. Soc. Biol. Paris, ire serie.*, vol. ii, p. 78, 1850. *Gazette Med. de Paris*, 1850.
- ¹² Karewski: *Klin. Chir.*, 1895, vol. xlix.
- ¹³ Morgagni: *De sed. et Caus. Morb. and Epistle 43, a. 10, u. and Epistle 50, p. 24*, 1740.
- ¹⁴ Morgagni: *De sed et Caus. Morb.*, 1761. (Translated by Benjamin Alexander.)
- ¹⁵ Morgan, J.: *Dublin Med. Press and Circular*, vol. iv, 1867.
- ¹⁶ Monod et Terrillon: *Traite Des Maladies du Testicule et de ses Annexes*, Paris, 1889.
- ¹⁷ Orr, J. A.: *Dublin Med. Press*, vol. xvii, 1847.
- ¹⁸ Paré, Ambroise: *Ouevres, C.*, 15, p. 196, 1564.
- ¹⁹ Park: *ANNALS OF SURGERY*, 1886. *Phila. Med. Times*, May 15, 1886.
- ²⁰ Scarpa: *Hernia Linea Alba. Sull' Ernie*, 1809.
- ²¹ Scarpa: *Traite Pratique des Herniæ*, 1812. Translation by Wishart, Edinburgh, 1814.
- ²² Watson, F. F.: *Hernia*, 1924.

TORSION OF AN INTRA-ABDOMINAL TESTIS

By JOHN K. ORMOND, M.D.

OF DETROIT, MICH.

FROM THE DIVISION OF UROLOGY OF THE HENRY FORD HOSPITAL

A MAN, aged forty-two years, married, and father of two children, was admitted to the Henry Ford Hospital as an emergency on October 7, 1923, complaining of pain in the right side of the abdomen of two days' duration. The pain had come on suddenly during coitus, had been intermittent in character, and had not been extremely severe. It had not radiated nor had it been accompanied by nausea, vomiting or urinary symptoms. There was no history of previous attacks.

There was nothing of great interest in the past history except that the right testicle had never been in the scrotum. Two years previous he had a left inguinal hernia repaired.

Except for the abdomen and external genitalia, the general physical examination revealed no striking abnormalities. The patient was a well-developed man, in no great pain; there was cloudiness of the left maxillary sinus, and chronic tonsillitis; the heart and lungs seemed normal, and the blood-pressure was 126/84.

There was some tenderness and muscular resistance on the right side of the abdomen, with its maximum at McBurney's point and a little below. No mass was palpable. The right testicle was absent from the scrotum, and could not be felt in the inguinal canal; the left testicle was apparently normal. The inguinal glands were not enlarged there was no urethral discharge; the prostate was normal in size, shape and consistency, and the expressed fluid showed about 25 per cent. pus cells. No hemorrhoids noted.

On admission the temperature was 98.4°, pulse 86. Leucocyte count 8200 with a polymorphonuclear percentage of 72. A few red blood-cells were found on the first urine examination but later examination showed no pus, blood, albumin or sugar. The blood Wassermann test was negative.

X-rays were taken of the urinary tract and no shadow suggestive of ureteral calculus was seen. Cystoscopy was done and failed to show any obstruction in the right ureter; the function of both kidneys was excellent and the pyelogram of the right kidney presented no unusual features.

The patient was observed for several days, his temperature rising to 99.8° on the second day of his admission and never rising above normal after that period; his pulse was never rapid and his leucocyte count never increased. He was never in extreme discomfort and had periods of complete comfort, but as his symptoms did not clear up, an exploratory operation through a right rectus incision finally was done. The pre-operative diagnosis lay between subacute appendicitis and some lesion of an intra-abdominal testis.

At operation there was found a mass consisting of a black swollen testicle, with one complete twist of its mesentery, and adherent to this mass was the tip of the appendix, which showed signs of very mild chronic appendicitis. The appendix and testicle were removed and recovery from operation was uneventful.

The case here reported is of special interest as only five other cases of torsion of an intra-abdominal testis could be found in the literature. They are of sufficient interest to be given in abstract.

I. GERSTER, in 1897, presented a patient before the New York Surgical Society. He was twenty-one years old, with third degree of hypospadias, absence of corpus spongiosum, and undescended testicles. The day previous to admission he had a sudden pain in the right iliac fossa, swelling developed and there was vomiting and fever.

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Examination showed a tender globular mass the size of a child's head in the right iliac fossa. At operation this mass proved to be the right testicle which was the seat of a malignant tumor and had become twisted on its pedicle.

2. STILES, in 1905, reported a case in a man thirty-nine years old. There had been sudden onset of severe abdominal pain with vomiting. He recovered from this in three days. There were four subsequent attacks, in the fourth of which he was seen by Stiles, who made a diagnosis of torsion of the right intra-abdominal testis and operated. At operation the testicle was found to be the seat of a sarcoma and had undergone torsion.

3. LECONTE, in 1907, reported the case of a young Italian, twenty-eight years old, who had been in good health until ten days before admission to the hospital. Then he had pain in the abdomen, anorexia, nausea and fever. Three days before admission the pain became severe, confining him to bed.

Examination showed general abdominal tenderness, especially in the right iliac fossa, where there was a sense of tumor and where there was marked rigidity. The right testicle was undescended; temperature 100.4° , pulse 96, respiration 22. Appendicitis seemed to have been suspected and operation was done. At operation an ovoid tumor the size of an orange was removed. The pathological diagnosis was sarcoma and torsion of the testicle.

4. HOWARD, in 1907, reported the case of a fifteen-year-old boy on whom he had operated two years before for bilateral undescended testicles. At that time he had replaced the right testicle in the abdomen and had brought the left down into the scrotum. Two years later he came complaining of pain under the operative scar on the right, with vomiting, and malaise of two days' duration. Examination showed tenderness under the scar but no tumor. Neither testicle was in the scrotum. At operation the testicle was removed and showed torsion.

Howard mentioned two cases of malignant tumor of the retained testis in which the appearance of the tumor was preceded by attacks of acute pain, which he thought were due to torsion.

5. CUPLER, in 1915, reported a case of torsion of an intra-abdominal testis which simulated acute appendicitis. The patient was a healthy man who had had no previous abdominal symptoms. The pain came on suddenly, was severe, and was followed by vomiting, rapid pulse, tenderness, rigidity in the lower right abdominal quadrant, elevation of temperature and a leucocyte count of 18,000. A diagnosis of either acute appendicitis or of torsion of an intra-abdominal testis was made. Operation showed a gangrenous testis with two complete twists to the cord.

OCCURRENCE AND ETIOLOGY OF TORSION OF THE CORD

The first report of a case of torsion was by Delasiuave in 1840. Operation was done for a supposedly strangulated hernia, and torsion of an inguinal testicle found. There followed at intervals isolated reports of cases until in 1901 Scudder reviewed the literature of the condition. Since then other cases have been added and reviews of the literature have appeared, by Rigby and Howard in 1907, Corner in 1907, Clute in 1919, O'Connor in 1919, Thorek in 1925 and Meltzer in 1926. In all about one hundred and fifty cases are on record.

It occurs most often in youth, at the age of puberty or in the first few years following, though there are several reports of instances at the age of a few days and a few at sixty or past. It has been observed at birth.

It occurs oftener on the right than on the left— $56\frac{1}{2}$ per cent. in one series and $59\frac{1}{2}$ per cent. in another. Incomplete descent with a developmental abnormality of the attachment of the cord to the testis seems to be the chief

predisposing cause. In one series 69 per cent. and in another 52 per cent. were undescended testes. It is probable that the failure to descend is only an indication of arrest of development. A fully descended testicle is usually a fully developed testicle, but under certain circumstances, an incompletely developed testicle may be completely descended, and *vice versa*. Since over half the recorded cases of torsion occurred in undescended testicles, it is easy to conceive that in the rest of them there was some developmental abnormality.

The etiological factors given are: 1. An abnormally loose scrotum. 2. A voluminous tunica vaginalis. 3. An unusually long gubernaculum. 4. An abnormal attachment of the cord to the testis.

From consideration of the anatomy and of the recorded cases the last two seem to be the most probable etiological factors. Ordinarily the reflection of the parietal layer of the tunica over the epididymis forms a mesentery running from the globus minor up to about the middle of the globus major. In most of the recorded cases of torsion this has been much shortened and includes only the globus major, and the twist has occurred in this very much shortened mesentery.

A consideration of the mode of descent of the testicle and the occasional findings at operation on hernias of the infantile type will show how this abnormality can occur. In operating on hernias of the infantile type, the epididymis is occasionally found more or less unravelled and attached to the testicle at the globus major only. It can easily be seen how a shortened mesentery, as described above, could occur as the testicle pushes the peritoneum in front of it in the descent. In such a case we would expect a long gubernaculum.

Discussion.—Including the case reported here, therefore, six cases of torsion of an intra-abdominal testicle have been found in the literature. In three, the testis was the seat of a malignant tumor and in one of the others it had been previously replaced in the abdomen by operation. In two, Cuplers and the one here reported, there was no complicating circumstance except the failure to descend. In only one, Stiles, was there a definite diagnosis made before operation.

It is interesting to note that in all the cases of torsion of an intra-abdominal testis reported, the right testicle has been the one affected. This is not true of torsion generally, though the right is affected oftener than the left, just as maldescent, which seems to be the chief etiological factor in the production of torsion, is commoner on the right than the left.

In one series of 77 cases of maldescent, in 39 cases the right alone was affected, in 23 cases the left alone, and in 15 cases the condition was bilateral. So it is evident that maldescent in general is commoner on the right side, and the statistics of torsion of the testis correspond pretty well to these figures, occurring oftener on the right than on the left, but not oftener than could be accounted for by the more frequent occurrence of the malformation on the right. But when we consider the statistics of abdominal retention and torsion a different story appears. Abdominal retention seems to be nearly as common

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on the left as on the right, and yet no case of torsion of a left intra-abdominal testis has been reported. I am not prepared to offer an explanation of this, but it seems reasonable to suppose that the presence of the cæcum with its intermittent loading and pull on the peritoneum must have something to do with this.

BIBLIOGRAPHY

- Attlee: *Lancet*, 1911, vol. ii, p. 761.
 Babcock: *Journal of American Medical Association*, vol. lxvi, p. 1699.
 Barney: *Urologic and Cutaneous Review*, 1922, vol. xxvi, p. 142.
 Begg: *British Medical Journal*, 1921, vol. ii, p. 843.
 Butler: *Surgical Clinics of North America*, 1923, vol. iii, p. 837.
 Clute: *Boston Medical and Surgical Journal*, vol. clxxxi, No. 8, p. 232, With Bibliography.
 Cohen, F.: *München Medizinische Wochenschrift*, 1921, vol. lxviii, p. 1668.
 Corner: *International Clinics*, vol. iv, 17th Series, 1907.
 Cupler: *Surgery, Gynecology and Obstetrics*, vol. xxi, p. 250.
 Dowden: *British Medical Journal*, vol. i, 1905, p. 932.
 Fournier: *Bulletins et Memoires de la Societe Anatomique de Paris*, 6th Series, vol. xviii, p. 377.
 Gerster: *ANNALS OF SURGERY*, vol. xxvii, p. 64.
 Going: *Lancet*, vol. i, 1906.
 Hagner: *Transactions of the American Association of Genito-urinary Surgeons*, 1919, vol. xii, p. 185.
 Hartmann and Renaud: *Bulletins et Memoires de la Societe Anatomique de Paris*, 6th Series, vol. xviii, p. 257.
 Hirsch: *Zentralblatt für Chirurgie*, March 14, 1925.
 Howard: *British Medical Journal*, 1907, vol. ii, p. 719.
 Keyes, Collings and Campbell: *Journal of Urology*, June, 1923.
 Le Conte: *International Clinics*, vol. iv, 17th Series, 1907.
 Lynn: *Bulletin of the University of Maryland*, vol. iv, No. 5, p. 199.
 McKay: *Surgery, Gynecology and Obstetrics*, 1923, vol. xxxvii, p. 373.
 Meltzer: *Journal of Urology*, vol. xv, No. 6, p. 601, With Bibliography.
 Munay: *British Medical Journal*, 1897, vol. i, p. 458.
 Nash: *British Medical Journal*, 1921, vol. i, p. 267.
 O'Connor: *Surgery, Gynecology and Obstetrics*, 1919, vol. xxix, p. 580, With Bibliography.
 Odione and Simmons: *ANNALS OF SURGERY*, vol. xl, p. 962.
 Parmenter and Counterman: *Buffalo General Hospital Bulletin*, 1923, p. 107.
 Rigby and Howard: *Lancet*, vol. i, 1907, p. 1415, With Bibliography.
 Rodd: *Journal Royal Naval Service*, vol. ii, 1921, p. 79.
 Scudder: *ANNALS OF SURGERY*, vol. xxxiv, p. 234, With Bibliography.
 Sonneland: *Surgery, Gynecology and Obstetrics*, vol. xl, p. 535.
 Stiles: *Transactions of the Medico-Chirurgical Society, Edinburgh*, 1905, vol. xxv, p. 5.
 Taylor: *British Medical Journal*, 1897, vol. i, p. 458.
 Thorek: *Interstate Medical Journal*, vol. xxvi, No. 3, p. 194.
 Thorek: *ANNALS OF SURGERY*, vol. lxxxi, p. 1142, With Bibliography.
 Weitz: *Deutsche Medizinische Wochenschrift*, Leipzig, 1923, vol. xlix, p. 381.
 Williams: *New York Medical Journal*, June 6, 1903.

LATERAL VENTRAL HERNIA *

BY ALEXIUS McGLANNAN, M.D.

OF BALTIMORE, MD.

FROM MERCY HOSPITAL CLINIC, DEPARTMENT OF SURGERY, UNIVERSITY OF MARYLAND

SPONTANEOUS ventral hernias are rare compared with the incidence of the inguinal, femoral and umbilical varieties. The epigastric type, in which the protrusion is through the linea alba is more common than lateral hernias outside the border of the rectus muscle. The great majority of these lateral hernias are found below the level of the umbilicus.

In spite of their relative rarity, ventral hernias have been recognized since the middle ages and have acquired a good-sized bibliography.

Guy de Chauliac distinguished between ventral and umbilical hernias. Astley Cooper ("Abdominal Hernia," 1807, and 2nd Edition, Philadelphia, Lea and Blanchard, 1844) gives as one reason for the occurrence of a hernia, the existence in the muscles and tendons of the abdominal wall of apertures for the passage of vessels and nerves, which, though naturally only large enough for that purpose, often become so relaxed as to allow the viscera themselves to protrude.

Discussing the situations in which abdominal hernias are found Cooper states, "Similar protrusions take place through the tendinous coverings of the anterior part of the abdomen. The linea alba and semilunaris are perforated to transmit vessels passing to the common integuments; when these holes are either originally of an unusual size, or are enlarged during a relaxed state of the body, hernias will occasionally be formed in them, which are called ventral." In addition to these apertures Cooper mentions as other causes for ventral hernia, defective development of the linea alba in children; wounds of the abdominal wall in the healing of which the muscles fail to unite, and a laceration of some of the fibres of the abdominal muscles under violent exertions or blows, which allows the peritoneum to pass between them. Of this last type he says, "I never, however, have ascertained this by dissection, but am disposed to believe it, from the sudden appearance of the disease after a sensation of laceration."

The greater frequency with which lateral ventral hernias are formed below the level of the umbilicus lead Moliere (*Bull. et mem. Soc. Chir.*, 1887, vol. cxi, p. 278) to suggest that the fold of Douglas determines the level of the protrusion. Macready ("A Treatise on Ruptures," London, 1893, p. 258) insists that in spontaneous ventral hernia the protrusion is through aponeurotic lines or spaces rather than through muscular tissue.

The subject is more prominent in foreign than in American literature. Coley (*ANNALS OF SURGERY*, 1909, vol. I, p. 246) reports a case. Cullen (*J. A. M. A.*, vol. lvii, p. 1251, and the "Umbilicus and Its Diseases," Fig.

* Read before the Southern Surgical Association, December 15, 1926.

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55) reports and illustrates a case in which the sac contained a multilocular ovarian cyst. Holloway (*ANNALS OF SURGERY*, 1922, vol. lxxv, p. 677) reviews the literature and gives a table of cases, as well as reports one of his own. Koljubakin (*Archiv. fur klinische Chirurgie*, 1925, vol. cxxxvi, p. 739) gives conclusions based on 30 dissections of the abdominal wall made to study the branches of the inferior epigastric artery as well as their relation to the aponeurosis of the transversalis and the sheath of the rectus. In addition he reports eight cases of lateral hernia and gives a historical study of the subject with an extensive bibliography.

The dissection showed arterial perforation of the linea Spigelii in about half the cases. Sixty per cent. of these perforations were unilateral, and most of them occurred at or near the point where a line drawn from the anterior superior spine of the ileum to the umbilicus would cross the outer border of the rectus muscle. The size of the openings in the aponeurosis varies from 4 to 18 mm.; in sixteen of the twenty measurements recorded the opening was between 3 and 7 mm.

Koljubakin describes the linea Spigelii as the boundary between the muscular and tendinous portions of the transversalis muscle, extending as a semilunar line from the level of the ninth or tenth rib to a point 2 cm. lateral to the spine of the pubis. The convexity of the curve is outward and reaches a point 5 cm. medial to the anterior superior spine of the ileum, on a line drawn from this bony prominence to the umbilicus. At the level of the tenth rib the semilunar line turns inward and fades out under the rectus muscle.

Holloway calls attention to the fact that there is no sharp line of demarcation at the junction of muscle and aponeurosis. The relative width of such junctions varies in different individuals. Therefore, the line of Spigelius is not fixed geometrically, but usually is represented by the outline described above. It would be better therefore to speak of the area between the outer border of the rectus muscle and the boundary described by Koljubakin as the semilunar space rather than the line of Spigelius.

A deposit of properitoneal fat is found between the serous membrane and the deep aponeurotic layer of the abdominal wall. A portion of this fat may penetrate one of the openings in the aponeurosis and pass through with the vessel. The collection of fat gradually increases in extent and finally forms a subperitoneal lipoma, one surface of which is firmly attached to the peritoneum while the remainder is through and outside the perforated aponeurosis. Gradually the movements of the oblique abdominal muscles make traction on the lipoma and this in turn draws a process of peritoneum after it through the aponeurosis to make a true hernial sac.

The hernia is an interstitial one lying between the transversalis and the oblique muscles. The pressure of large and long-standing irreducible hernias may thin the bundles of the overlying internal oblique to a degree of practical destruction, or the lipoma may spread the muscle bundles apart, but the firm aponeurosis of the external oblique is not perforated. The neck of the sac may be a long narrow tube passing obliquely through the opening in the

aponeurosis to connect the ring of protrusion with a vagrant fundus and properitoneal lipoma which forms a swelling at a considerable distance from the opening.

When the opening in the aponeurosis and the lipomata are related in size the entire mass may be reducible. Sometimes the true hernial contents can be reduced, but the lipoma remains outside the transversalis aponeurosis. Often the entire hernia is irreducible and because of the narrow opening in the firm aponeurosis is prone to strangulation.

Atrophy and relaxation of the musculature of the abdominal wall from any cause as well as developmental anomalies of these structures are factors in the etiology of these hernias in addition to those associated with penetration by the vessels. Great increase in the fatty layers of the abdominal wall is an important factor, and often the hernia is noticed after such an adiposity undergoes atrophy.

In the earlier literature Spigelian hernias were reported as occurring more often in women than in men and repeated pregnancies were considered the responsible factor. Thirty-four cases collected by Koljubakin from reports during 1923 and 1924 were evenly divided between the sexes. The condition is one of middle life or later age. Most of the patients are beyond forty, many of them between sixty and seventy years of age at the time of onset of symptoms.

If the size of the hernia and its neck allows protrusion of a visible and palpable mass when the abdominal tension is increased and subsequent reduction of the swelling by manipulation, the diagnosis of a hernia is certain and the identification of the variety rests on the localization of the neck within the limits of the Spigelian area.

Small hernias and those in which the lipoma cannot be reduced offer difficulties in diagnosis. The lipoma and the small hernia may be impalpable in the thick abdominal wall. Localized pain and a persistent tender point may mark the seat of the hernia. When pressure at the tender point produces a gastro-intestinal reflex such as belching, nausea or cramps, the presence of a hernia should be suspected.

The symptoms of subacute and chronic appendicitis, cholecystitis, pelvic disease and renal colic may be confused with those of a cryptic hernia.

The absence of inflammatory phenomena as fever, leucocytosis, pain on distant pressure, and of muscle spasm and rigidity with the different clinical history of the diseases usually allows us to separate appendicitis and cholecystitis from these hernias. Cholecystography will aid in the recognition of the diseased gall-bladder. Similarly the urological and X-ray examinations will identify the kidney lesions and gynecological examination the pelvic disorders.

When the irreducible lipoma is the most prominent sign of the hernia, the diagnosis from other varieties of tumor of the abdominal wall is not always easy to make. The lipoma and hernia under pressure of the oblique muscles,

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with certain reflex disturbances of digestion, may suggest a malignant tumor of the bowel.

In spite of all our methods of examination and study certain of these hernias cannot be recognized. In such cases the persistent localized pain and tenderness, especially if these symptoms are intensified by exertion or the erect posture, justify an exploration of the region on the probability of finding a Spigelian hernia. When found, such a hernia requires for its cure, removal of the sac after closure of its neck, and repair of the opening in the aponeurosis and muscles by proper suture.

Following is the report of a hernia of the linea semilunaris Spigelii which came under my care at the Mercy Hospital in April, 1926. The hernia is one of the rarer variety situated above the umbilical line.

No. 47,804. The patient was a white man, age fifty. Eight months before admission after playing a game of golf, he noticed a little puff on the left side of the abdomen which he thought became larger when his stomach was distended with gas. He was apprehensive concerning the possibility of a malignant tumor of the bowel. He was well nourished but not fat, and had not lost weight. On the left side of the abdomen, about an inch above the level of the umbilicus and two inches outside the border of the rectus muscle, there was a smooth, firm, immovable tumor, which was distinctly recognized as being situated under the external oblique muscle. The mass was not tender and manipulation did not cause pain. Except for this tumor the physical examination was negative. Laboratory examinations of the blood, urine and stools were negative as was an X-ray study of the gastro-intestinal tract. A diagnosis was made of fibroma of the abdominal wall situated under the external oblique muscle.

Operation, April 30, 1926. McGlannan.

Under ethylene anæsthesia an incision was made over the tumor. The external oblique was split in the direction of its fibres. The globular tumor, a fibro-lipoma about one and one-fourth inches in diameter, was found between the two oblique muscles. Connected with the deep surface of the tumor there was a tubular process of peritoneum about one-fourth of an inch in diameter, which went down between the muscular fibres of the internal oblique. These fibres were separated and retracted to expose the neck of the tube passing through an opening in the transversalis aponeurosis just at its junction with the fleshy bundles. Several small blood-vessels ran around the sac at this opening which was about one-half of an inch in diameter.

An adherent epiploica and a loop of large intestine could be seen through the translucent sac moving with each respiratory action. The sac was opened, the adherent bowel freed and dropped back. The neck of the sac was then closed with catgut and the remainder excised and removed with the lipoma. Each of the three muscle layers was sutured separately with catgut and the skin closed with equisatine. The patient recovered without any complications and has been relieved of his symptoms.

Greater consideration of the history of onset of the tumor might have led us to a correct diagnosis of lateral hernia, but the absence of any of the ordinary signs of hernia and the freedom from local pain and tenderness, with the presence of a firm immovable tumor did not suggest such a possibility to us.

TRANSACTIONS OF THE PHILADELPHIA ACADEMY OF SURGERY

Stated Meeting Held November 1, 1926

The Vice President, DR. ASTLEY P. C. ASHHURST, in the Chair

FOREIGN BODY IN THE BLADDER

DR. JAMES H. BALDWIN reported the history of a man, aged twenty-two, who was admitted to the Methodist Hospital, March 22, 1925, with the history that for a year he had suffered with a severe bladder irritation, with

increasing frequency of urination and marked dysuria. No history as to etiology could be obtained from the patient, although he was of course definitely aware of the cause. An X-ray taken showed a vesical calculus containing a foreign body. (Fig. 1a.)

This was removed through a suprapubic incision. The patient made a prompt and uninterrupted recovery. The

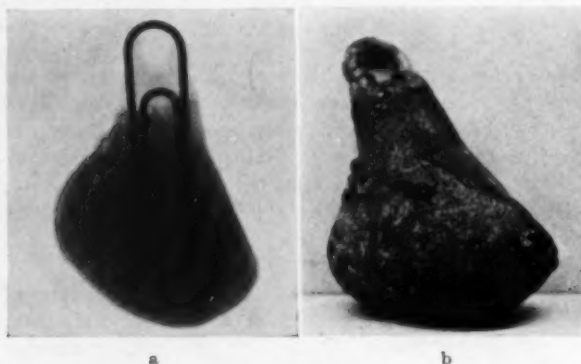


FIG. 1a.—Skiagraph of paper clip encrusted with urinary salts.
b. Encrusted paper clip removed from bladder.

foreign body was found to be a paper clip encrusted with urinary salts. (Fig. 1b.)

OBLITERATIVE ENDOANEURISMORRHAPHY FOR POPLITEAL ANEURISM

DR. J. STEWART RODMAN presented a man, aged fifty-six, who was admitted to the Presbyterian Hospital, May 6, 1923, complaining of swelling in left popliteal space.

About two years ago, patient first noticed swelling in left popliteal space about the size of a walnut, which has gradually increased in size. It was never painful until about a month ago, when walking home from work, he was seized with cramp-like pains in leg. He went to bed for three days; but had had no pain for two weeks prior to admission.

Examination revealed a pulsating mass in the course of the popliteal artery. The blood Wassermann was negative.

May 10, 1926.—An incision about four inches long was made in the left popliteal space and the popliteal artery exposed. A small aneurism was found. The vessel was clamped above and below and the aneurism opened. A well-formed clot was removed and both ends of the aneurism obliterated. The wound was closed in the usual manner. Convalescence was complicated by a slight wound infection and a bronchopneumonia.

PERSISTENT SKIN ULCERATION IN AXILLA

Six weeks after the operation, the wound was clean, but the leg slightly swollen. This disappeared by the time of his discharge from the hospital, July 25, 1926, ten weeks after operation.

When seen three weeks ago, there was no further trouble with the leg and no intermittent claudication. The foot on the operated side was as warm as its fellow. The posterior-tibial pulse cannot be felt on the operated side.

PERSISTENT SKIN ULCERATION IN AXILLA

DOCTOR RODMAN presented a second patient, a man, aged thirty-three, who was admitted to the Womens College Hospital, July 23, 1924, complaining of a painful mass in left axilla.

Five months prior to admission he had an infected index finger of the left hand, which healed slowly. Five weeks prior to admission, he first noticed a small mass in left axilla, which gradually increased in size. Two weeks prior to admission the mass had been lanced in the dispensary. He stated that he had had blood poisoning in 1911, scarlet fever in 1915, electric burns of arms, hands and face in 1922, and occasional attacks of renal colic on the right side.

Examination revealed palpable lymph-nodes in the neck and inguinal region. There was an erythematous, irregular flush over the neck and upper part of sternum, but none on the chest or abdomen. Scars of old burns were present over both hands and arms, and the left arm was painful on motion. In the left axilla there was a non-fluctuating swelling, which was incised and a small amount of pus was evacuated and the wound packed with Dichloramine-T. Examination of blood revealed a polymorphonuclear leucocytosis with slight secondary anaemia. The blood Wassermann was negative.

Discharged to out-patient department on August 4, 1924, and made daily visits, until December 27, 1924. The lesion refused to heal completely. As it healed in one direction it spread in another, having resisted all treatment. He was readmitted on February 17, 1925. X-ray examination of the chest failed to show evidence of bone involvement around lesion in left axilla.

At this time the edges of ulcer were curetted and packed with iodoform gauze. The pathologist reported that the sections showed probable tuberculous granulation tissue. No evidence of pulmonary tuberculosis could be found. The affected area grew gradually larger, extending to the arm.

September 30, 1925, he was readmitted, the area cleansed, and wet dressings applied, and on October 2, 1925, the edges were again curetted and the entire area skin-grafted. A second pathological examination of curettings resulted in a diagnosis of tuberculosis of the skin.

When he was discharged November 19, 1925, most of the grafts were lost, but a few remained healthy. He was then referred to the dermatological clinic. Mercury and iodides were administered empirically but without effect. At the present time, the condition of the patient is substantially unchanged.

DR. J. VICTOR KLAUDER remarked as to the pathology of this case that the pathologists did not agree to the diagnosis of tuberculosis. The consensus of opinion was that it was not a true picture of tuberculosis of the skin. Epithelioma can be ruled out clinically as well as histologically. Chancroid may also be ruled out. It fits best into that type of ulceration described by Sutton, of Kansas City, as tropical ulcer. Etiologically, it is variety of spirochætal infection; other investigators have found the spirochæte in this form of ulceration.

PHILADELPHIA ACADEMY OF SURGERY

The study of these cases should always include a dark field examination and a histologic examination for spirochaetes. There is also described a rapid ulcerative process.

The treatment of these cases is difficult. Neoarsphenamine should be used; it does serve a useful purpose, probably because some of them are infectious cases. In addition it is well to use general antiseptic and dietetic treatment. Another feature which was eliminated in diagnosis was granuloma inguinale. The question of a dermatitis self-produced was brought up, but there seemed to be no motive for such, and the man seemed to be emotionally normal.

DOCTOR RODMAN stated that in connection with Doctor Klauder's remarks concerning the fact that this case best fitted into that type described as tropical ulcer, it might be mentioned that the patient had just informed him that he spent fifteen years in the tropics—Panama and Colombia.

RECURRENT HÆMATEMESIS DUE TO SPLENIC ANÆMIA, APPENDICITIS AND CHOLELITHIASIS

DR. DAMON B. PFEIFFER reported the case of a woman, aged thirty, white, American, who was admitted to the Presbyterian Hospital, July 1, 1926, with a typical attack of appendicitis which had begun the previous day. Fourteen months previously she had been referred to the reporter for an opinion on account of recurring severe gastric hemorrhages. She was then twenty-nine years old. The family history was negative. Except for mild scarlet fever and mumps her only indispositions had been occasional attacks of nausea and vomiting called bilious attacks. At times she thought she became yellow, but no definite history of jaundice was obtainable. Her digestion was good and she was considered the healthiest one of a large family. There was no history of malaria or suspicion of syphilis, later verified by a negative Wassermann. At the age of nineteen, without premonitory symptoms or known cause, she suddenly became nauseated and vomited a huge quantity of bright red blood and clots. This was repeated five times during several days and she became weak and anæmic. Recovery, however, was then rapid and she felt well, having no symptoms, digestive or otherwise. Since then at irregular intervals of several years she has had similar attacks of profuse hæmatemesis coming on without warning and persisting until she was almost exsanguinated, followed by rapid and symptomatically complete recovery. She never had had purpura but just before her first hemorrhage she says that she had a tooth pulled and bled profusely.

She was a well-nourished, healthy looking woman of clear complexion, not anæmic at this time and the abdominal examination was entirely negative. She was not again visited until she came into the hospital in this attack, fourteen months later, having been entirely well in the meantime.

At operation, which was performed immediately, he explored the upper abdomen before disturbing the region of the appendix. The gall-bladder was thickened and smaller than normal. The stomach and duodenum presented no abnormality to palpation. The spleen was markedly enlarged and extended down to, but not below, the costal margin. It was not deemed advisable to carry out any upper abdominal procedure at this time on account of the condition of the appendix which was gangrenous throughout and buried beneath the cæcum and ascending colon. It was evident that chronic disease had long antedated the acute attack. The appendix was removed, a drain

RECURRENT HÆMATEMESIS DUE TO SPLENIC ANÆMIA

placed in the bed of the appendix, emerging through a stab-wound in the loin, and the anterior wound closed. The next day she vomited eight ounces of blood and thereafter continued to pass tarry stools for several days, becoming very anæmic and weak. Aside from hemorrhage, the abdominal condition was entirely satisfactory. The abdominal wound was healing by first intention and the drainage in the loin was moderate and of the usual fetid character seen in bacillus coli infections.

July 8 the blood count was as follows: Hb. 30 per cent., red blood-cells 1,590,000, white blood-cells 15,850. July 12 she received a pint of blood by the citrate method and suffered a slight reaction a few hours later. Her convalescence after this was uneventful. She recovered rapidly. August 6 the blood showed Hb. 45 per cent., red blood-cells 2,580,000, white blood-cells 4000. She was discharged August 8.

It was intended to have her return to the hospital later for cholecystectomy and splenectomy, with a view to obviating, if possible, further hæmatemesis. She was troubled slightly with indigestion, but continued to improve until September 3, 1926, when she was awakened at 3 A.M. by a desire to go to stool. She went to the bathroom, passed a tarry stool, and vomited a large amount of blood. In the next two days she had six severe hemorrhages. The following day she was brought to the hospital and was given 5 c.c. of thromboplastin, intramuscularly. September 5, she was given 500 c.c. of blood by the citrate method. No reaction followed but the day following she vomited about the same amount of blood that she had received. Two days later another small hemorrhage occurred following which there was no further hæmatemesis. At this time the blood count showed Hb. 20 per cent., red blood-cells 1,270,000, white blood-cells 4400. She was again transfused without reaction. Following the cessation of hemorrhages, her recovery was rapid. October 15 the blood showed Hb. 55 per cent., red blood-cells 2,850,000, white blood-cells 5300; coagulation time five minutes; bleeding time two and a half minutes. The following day, almost eleven years from the date of her first hemorrhage, the reporter removed the spleen and the gall-bladder. Another transfusion was given before she left the table. The spleen had increased in size, its lower border being three finger-breadths below the costal margin. There were no adhesions. The vasa brevia were large and thin-walled. The attempt to deliver the spleen in order to attack the pedicle from behind, ruptured some large vessels in the lieno-phrenic ligament and the attempt was abandoned, the bleeding being controlled by a gauze pack. The pedicle was then divided anteriorly in sections and tied and the organ removed without much loss of blood. It was noteworthy that all vessels, including those in the abdominal wall, showed an increased tendency to bleed. The torn vessels posteriorly were secured with a snaking suture. The gall-bladder was thickened and adherent to the duodenum and very atrophic. It was removed and the cystic duct tied. Both duct and gall-bladder contained pultaceous precipitated bile salts. The cystic duct was tied and an attempt made by suture to control oozing from the cystic fossa. The liver was so soft, however, that this had to be abandoned. Oozing was controlled by pressure with a gauze pack for a few minutes. The operation was performed through a left rectus incision and a stab drain placed through the right rectus muscle into the cystic fossa. The liver was dark, congested, and as previously stated, unusually soft rather than cirrhotic. The stomach and duodenum showed no visible or palpable abnormality other than the varicosity of the vasa brevia above mentioned. The incision was closed without other drainage. Convalescence was uneventful.

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The blood count, October 30, showed Hb. 65 per cent., red blood-cells 3,310,000, white blood-cells 6600. Differential, polymorphonuclears 55 per cent., small lymphocytes 11 per cent., large lymphocytes 2 per cent., large mononuclears 11 per cent., eosinophiles 14 per cent., basophiles 4 per cent., megalocytes 4 per cent. Poikilocytosis and anisocytosis; no normoblasts. Reticulated cells 4 per cent., blood platelets 450,000 per c.c.

DOCTOR PFEIFFER remarked that the explanation of profuse gastric hemorrhage, and therefore the appropriate procedure to be used in treatment, are often difficult. The pathology of certain types is sufficiently clear, such as the erosion of a vessel in the bed of an indurated ulcer, benign or malignant, or the rupture of an œsophageal varix. Benign tumors such as myoma or polyp, while uncommon, may bleed profusely. On the other hand, the source of the bleeding and reason therefore are not always apparent. The descriptions of so-called mucous erosions are not convincing as an explanation of massive gastric hemorrhage and to most of us this conception seems scarcely more than a refuge when the actual source remains unknown as may well happen in the difficulties and dangers of complete examination under clinical conditions. The "exulceratio simplex" of Dieulafoy seems better attested and there is no reasonable doubt that on occasions an acute gastric ulcer may open a vessel of sufficient size to provide alarming hemorrhage. The rôles of toxic states, infective or otherwise, of jaundice and blood dyscrasias, of coexistent disease of the appendix or gall-bladder in gastric hemorrhage are far from clear. It is certain, however, that certain splenic enlargements are prone to be associated with gastric hemorrhage and in several fatal cases large varicose veins in the fundus of the stomach have been found post mortem, erosion into one of which veins has been the source of the hemorrhage. It is not necessary that the liver be cirrhotic in all cases of varicose veins of the stomach. In the case of splenic enlargement it seems probable that the greatly increased blood supply to the spleen results in a similar increase in that of the fundus of the stomach through the left gastro-epiploic which in time causes enlargement of the drainage veins of this area. Presumably the hemorrhages of splenic anæmia are due to the ease with which superficial erosions of the gastric mucosa may open a vessel of considerable size. Hence it is that such hemorrhages are apt to recur even after the spleen has been removed, since the change in the venous channels must be permanent to a considerable extent. That these cases are less often fatal than massive, bleeding from callous ulcer may be due not only to the fact that in ulcer the vessel lies in fibrous tissue and is unable to retract or contract, but also because the bleeding vessel in ulcer is often an artery while in splenic anæmia it is a large venous channel containing blood under low pressure. Splenectomy is the treatment of choice and in many cases has resulted in cessation of hemorrhages. In late cases, however, bleeding often recurs. During the stage of active hemorrhage operation is inadvisable and these cases rarely die of acute loss of blood unless their general health is depleted as in the later stages of the disease. Supportive measures, with transfusion

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if danger becomes acute, will usually bring the patient into condition for an interval splenectomy.

DR. JOHN B. DEEVER remarked that he sees a number of these cases; only recently he operated upon a similar case where the only symptom was hæmatemesis. In his experience the hemorrhages frequently recur even after ten or more years of supposed cure. A number of such cases have resulted fatally. He sees more liver changes, personally, than are reported in the literature and a small percentage with extensive ascites; this, however, does not prevent recovery after splenectomy. The condition, in his experience, is not at all uncommon.

DR. JOHN EIMAN demonstrated lantern slides made from colored photographs, of the specimens removed at the operation upon Doctor Pfeiffer's patient. The photographs were made by the new German process, which is somewhat similar to the lunear but which gives a much finer differentiation. The process is comparatively simple, and anyone familiar with ordinary photographic work can, with a little experience, prepare these color plates. It is impossible to reprint them on paper except by a three-color process, which is very expensive. The advantages of having a permanent and accurate record of this type are very great.

GAS GANGRENE IN CIVIL SURGERY

DRS. JAMES H. BALDWIN and WILLIAM R. GILMOUR read a paper with the above title, for which see page 161.

DR. JOHN EIMAN recalled two cases of gas gangrene which had occurred at the Presbyterian Hospital and had possibly been reported by Doctor Jopson.

One was a colored boy whose biceps was cut. The serum saved his life.

The second case was a case of ruptured appendix with localized peritonitis. Hypodermoclysis of salt solution was given and 24 hours later the patient developed gas gangrene at the site of puncture. The possibility of infection having been carried under the skin by the hypodermic needle was considered, but this could be eliminated. The literature disclosed the fact that German writers had reported similar cases. They have been able to prove definitely that these individuals had in their systems and possibly in their blood streams some of the gas bacilli and the needle produced trauma sufficient to start trouble.

DR. THOMAS SHALLOW said that he had seen a case of this kind the year before last at the Blockley Hospital. The patient had a hypodermic syringe used at 9 P.M. and was dead at four the next morning from gas gangrene. The patient was under treatment for cardio-renal disease.

He recalled another case in the Philadelphia Hospital which would seem to be gas gangrene, from all the symptoms. The patient had a head injury, due to a blow from a foreign body. Gas gangrene developed. In neither of these cases was there any crushing injury, such as is usually described as preceding gas gangrene.

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DR. DAMON B. PFEIFFER remarked that he saw a case of gas gangrene several years ago following a hypodermic injection. The injection was given in the morning and in the middle of the day the gas gangrene infection was present. By four o'clock the patient was dead. He is particularly interested in the remarks made by Doctor Eiman. It was felt that some one in the hospital might have had something to do with the introduction of the infection. They never thought of the patient's having had the infection and the hypodermic injection merely being responsible for its localization.

SURGICAL PATHOLOGY OF THE GALL-BLADDER

DR. V. G. BURDEN read a paper with the above title, for which see page 239.

DR. JOHN B. DEAVER said that biliary cirrhosis, the result of gall-bladder disease, should be mentioned. He recalled the case of a prominent Philadelphian who was operated upon for this condition. He is now seventy years of age, and is better than he was ten years ago, before he had any trouble. This is the result of prolonged common duct drainage.

TRANSACTIONS

OF THE

NEW YORK SURGICAL SOCIETY

Stated Meeting Held November 10, 1926

The President, DR. WALTON MARTIN, in the Chair

LATE RESULTS FOLLOWING PARTIAL GASTRECTOMY FOR CARCINOMA OF THE STOMACH

DR. RICHARD LEWISOHN presented two patients upon whom he had operated for carcinoma of the stomach at Mount Sinai Hospital ten and seven years ago. The first patient, now sixty-five years old, was admitted to the surgical service ten years ago. He had complained about epigastric distress for two months and had lost thirty-five pounds. The hæmoglobin was 41 per cent. X-ray examination demonstrated a large pyloric carcinoma. The test-meal showed free HCl absent; blood present; Boas-Appler bacilli present. On exploration a large pyloric carcinoma was found which was adherent to the pancreas, but did not invade this organ. A partial gastrectomy with Murphy button gastro-enterostomy was performed. Pathological report showed colloid adenocarcinoma.

The patient developed an empyema three weeks after the operation. The empyema was drained through an intercostal incision under local anaesthesia. After this secondary operation the recovery was uneventful. The patient returned to his original occupation (conductor) and he is still active in this profession at present. He has gained sixty pounds since his operation, ten years ago, and is in perfect health.

The second patient, now seventy years old, complained of epigastric distress for four months before his admission in 1919. The operation revealed a very large indurated mass, occupying about three-quarters of the stomach in its whole circumference. A subtotal gastrectomy with Murphy button gastro-enterostomy was performed. Microscopical examination showed carcinoma solidum.

The patient has been in perfect health since this very extensive resection seven years ago.

DOCTOR LEWISOHN stated that he was well aware of the fact that recurrences usually followed operations for carcinoma of the stomach after a comparatively short interval. For this reason many surgeons hesitate to advise operation, especially in the presence of large tumors. However, occasional radical cures, such as those presented herewith, make it imperative to attempt a removal of the tumor, as long as the growth is still confined to the stomach.

While the Murphy button is rarely used at present, the results obtained in these cases demonstrate that this little instrument should not be entirely discarded, as it simplifies the anastomosis in very extensive resections.

CARCINOMA OF SPLENIC FLEXURE OF COLON

DOCTOR LEWISOHN presented a man, who was admitted to the medical service of Mount Sinai Hospital on December 15, 1922. He was twenty-seven years old at the time of his admission. He gave the following history: Ten

months ago he had suffered from rectal bleeding on three occasions, and a surgeon had performed a hemorrhoidectomy. Eight weeks ago he noticed pain in the left upper quadrant. Two weeks ago he had some chills and three days ago he noticed tarry stools. His temperature during the observation period on the medical service ranged between 101 and 102. Palpation revealed a hard, tender mass in the left upper quadrant. X-ray examination showed a constriction at the junction of the transverse colon and splenic flexure.

He was transferred to the surgical service. Operation through an incision along the left costal border revealed a hard mass in the splenic flexure. After the peritoneal cavity had been protected by packings, a pericolic abscess was entered, containing one ounce of pus. The abscess cavity communicated with the lumen of the colon. The tumor was densely adherent to the anterior abdominal wall and the diaphragm. These adhesions were divided. The gastro-colic ligament was then ligated and the blood supply of the splenic flexure tied off. A Mikulicz "vorlagerung" was performed in typical fashion and the incision was closed, allowing ample room for drainage.

The tumor was removed two days following the operation. Microscopical report: adenocarcinoma. The patient made an uneventful post-operative recovery. The spur was crushed on January 22, with the use of Stetten's enterotribe. Four weeks later an extraperitoneal closure of the artificial anus was effected and the patient was sent home March 21 with the fistula practically closed.

One month after his discharge from the hospital a number of abscesses formed around the fistula and the colostomy broke open again, most of the stools passing through the colostomy.

He was re-admitted October 6, 1923. An intraperitoneal closure of the colostomy was performed which healed by primary union.

He is now in perfect health, four years after the operation, and has gained fifty pounds.

DOCTOR LEWISOHN stated that he presented this patient in order to show that in spite of the fact that carcinoma is usually of a most malignant nature in young individuals, excellent results can be obtained occasionally by radical removal of the growth.

The second patient, sixty years old, was admitted to the surgical service of Mount Sinai Hospital, September 13, 1924. He had suffered from an incomplete obstruction three months previous to his admission. The attack lasted for three days. His symptoms recurred September 11, 1924.

Examination revealed a slightly distended abdomen without visible peristalsis. On the day following his admission he had marked cramps and vomited. X-ray enema showed an incomplete obstruction at the splenic flexure and marked dilatation of the transverse colon.

Operation.—September 15: The abdomen was opened through an incision along the left lower border of the ribs. A small scirrhous carcinoma was found at the splenic flexure. The proximal colon was markedly dilated, the distal colon was collapsed. A Mikulicz "vorlagerung" was performed. Closure of the incision in layers. The tumor was resected with the aid of a cautery ten days after the operation.

A microscopical examination could not be made, as the resected gut was completely gangrenous.

The patient made an uneventful recovery and left the hospital on October 11. He was readmitted for a few days for division of the spur with the aid of an enterotribe. An extraperitoneal closure of the colostomy was effected by Doctor Klein in January, 1915.

RESECTION OF SIGMOID AND BLADDER FOR CARCINOMA

DOCTOR LEWISOHN stated that while he favored primary resection in the absence of obstructive symptoms, the Mikulicz "vorlagerung" should be the method of choice in any case showing signs of obstruction.

RESECTION OF SIGMOID AND BLADDER FOR CARCINOMA WITH FIVE YEAR CURE

DR. DEWITT STETTEN presented a woman, sixty-five years of age whom he first saw with Dr. Otto Hensel December 3, 1921. She gave a history of

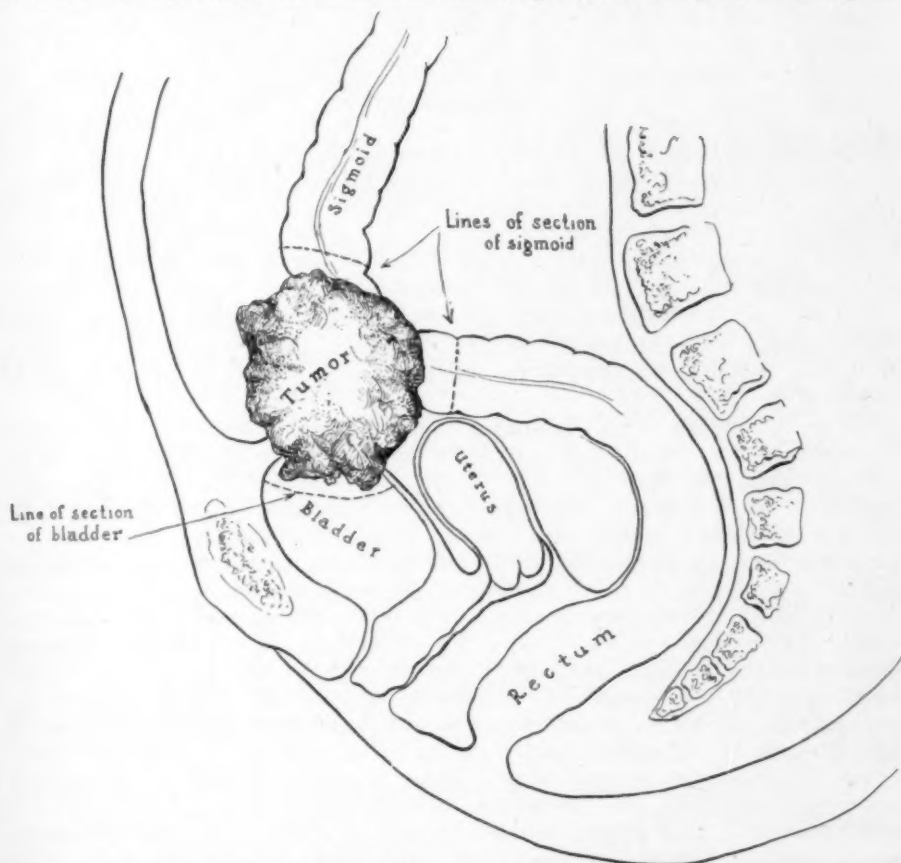


FIG. 1.—Diagram showing relations of adenocarcinoma of sigmoid involving bladder, and lines of resection.

having been passing blood in her urine for a short time. She had had no symptoms referable to her intestinal tract. A cystoscopy had been performed by Dr. Herman R. A. Graeser which showed a large, ulcerating tumor, obviously a carcinoma, at the posterior wall of the bladder near the vault. On abdominal examination a hard, irregularly spherical, rather fixed mass, about the size of a small orange, could be felt just above the symphysis, which could be easily palpated bimanually. Her urine was red and cloudy and showed a large quantity of blood and pus. On December 6, 1921, on the assumption that the lesion was a large ulcerating carcinoma of the vault of the bladder, a suprapubic cystotomy was performed through the anterior wall of the bladder, and a large, friable, ulcerating area exposed on the posterior wall of the bladder near the vault. It was soon seen, however, that

this tumor extended intra-abdominally behind the bladder, and further, that fecal material entered the bladder from the ulceration. The abdomen was opened. It was now seen that the tumor was obviously a large primary neoplasm of the sigmoid attached to the posterior wall of the bladder near the vault and perforating into this organ (Fig. 1). Although the operability of the tumor was questionable, a wide elliptical excision of the posterior wall of the bladder was then performed well beyond the invaded area and both the posterior wall defect and the anterior superior suprapubic opening were closed in the usual manner, leaving a somewhat conical bladder after suture. The tumor, which was very adherent to the adjoining tissue, was freed with considerable difficulty, a typical resection of the sigmoid well beyond the neoplasm, with end-to-end anastomosis by suture was then done. Good approximation with a satisfactory lumen of the gut was obtained and the mesenteric defect was closed. The usual drainage was introduced and the abdominal wound was sutured. An indwelling catheter was placed into the bladder. Examination of the specimen showed it to be a large, ulcerating, papillary tumor of the sigmoid, invading the entire lumen and perforating at a point opposite the mesentery of the intestine and invading the bladder for an area of at least one and a half inches in diameter. There was only very slight stenosis of the lumen of the gut. No mesenteric glands could be found. Microscopical examination by Dr. Frederick D. Bullock showed the tumor to be an adenocarcinoma of the sigmoid with extensive involvement of the bladder.

The patient had a rather stormy convalescence. There was considerable sloughing of the wound and a urinary fistula developed. About two weeks after operation a fecal fistula developed; but, however, this was apparently from the small intestine judging from the character of the discharge, the absence of flow into the fistula upon rectal irrigation, and the fact that ingested food soon appeared at the fistula. This fistula was probably due either to the infection or to erosion of the small intestine from the drains. Neither fistula showed any tendency to close in spite of every effort at treatment. The patient ran down very rapidly and the skin around the wound became greatly irritated in spite of the greatest possible care. Pain developed over the pubis especially on the right side, and X-ray examination showed some fuzziness, mottling and loss of detail of both pubic bones which Dr. William H. Stewart regarded as characteristic of carcinomatous metastases. In spite of this discouraging report from the röntgenologist, on April 12, 1922, reoperation was undertaken to close both fistulae and to inspect the pubic bones. Under general anaesthesia the old scar was excised around the fistulae and all granulation tissue thoroughly curetted out. The pubic bones both showed evidence of disease, particularly the right. They were soft and there were several loose spicules of necrotic bone found. The diseased bones were thoroughly curetted and more soft necrotic bone with considerable granulation-like tissue was removed. This condition of the pubic bones resembled more an infectious condition by direct extension from the wound, than a neoplastic invasion. The opening of the fecal fistula was exposed and the peritoneal cavity opened. The fecal fistula was found to arise from a loop of ileum which was very densely adherent to the abdominal wall. This intestinal loop was loosened and the fecal fistula closed in the usual fashion. Other adherent intestinal loops were freed. The opening in the bladder was now carefully exposed, freed and closed in the usual manner by a double layer of chromicized catgut sutures and a flap of peritoneum was laid over the suture line. No opening could be found at the sigmoid suture but this region was densely adherent to the posterior wall of the bladder, although

RESECTION OF SIGMOID AND BLADDER FOR CARCINOMA

there was apparently no communication between the gut and the bladder. This area was not disturbed. Drainage was inserted, the wound closed in the usual manner, and a permanent catheter was left in the bladder. Microscopical examination by Dr. Frederick D. Bullock, of the tissue removed by the curette, showed it to be suppurative granulation and inflammatory fibrous tissue with no evidence of carcinoma. Two days after operation there was a slight leakage of urine along the abdominal drains, apparently because the catheter had become clogged. After the catheter was cleaned the drainage of urine from the wound greatly diminished. Twelve days after operation the wound was granulating nicely, and there was no evidence of fecal or urinary leakage. One month after operation the catheter was withdrawn. There was no sign of either urinary or fecal leakage from the wound which was rapidly closing. Immediately after the withdrawal of the catheter, patient held her urine from two to three hours, passing from two to four ounces of clear urine at a time. She was discharged from the hospital, May 16, 1922, weighing eighty-eight pounds. Within a month the wound was entirely healed and the patient steadily began to improve. The patient feels perfectly well today. She has had no symptoms referable to either her intestine or her bladder since. There is no particular frequency of urination and she voids normal quantities of clear urine. Abdominal examination shows a fair sized, post-operative ventral hernia at the lower angle of the hypogastric wound. Vaginal and rectal examination are negative. There is no evidence of recurrence. She now weighs 147 pounds, which is seventeen pounds heavier than her normal weight before the operation.

This case demonstrates the relative benignity of certain types of colon carcinomata, and is a plea for radical surgery even in cases that apparently border on inoperability.

DR. JOHN DOUGLAS remarked that there is a great deal of pessimism existing as to the end-results of operation in carcinoma of the stomach, but the difficulty lies in the fact that most of these cases do not appear early enough to get good results, and probably never will. The speaker was doubtful if it was possible to tell from the gross pathology in which cases recurrence was most likely to happen, and he agreed with the doctrine that so long as there is a chance, it is worth while to operate radically on these patients. He remembered one case in which there had been a visible, palpable tumor for over a year and the patient lived for nine years after operation, and was then lost track of. He remembered too, a large number of patients who lived five years and more, two or three being still alive seven and eight years after sub-total resection. On the other hand, he recalled cases, one of which he had operated on a year ago, in which the tumor was so small one could not distinguish it from an ulcer, which had recurrence in the neighboring glands of the stomach within a year.

DR. GEORGE WOOLSEY referred to his report of two advanced cases in which the results of operation surprised and gratified him, one living and well thirteen years and the other ten years after operation. Not only that, but in cases where a permanent or a long recovery cannot be expected there are often unexpectedly good results. He remembered one old man with a tumor as large as an orange who begged for an operation and who lived for two years after operation, in perfect comfort for twenty-one months although he

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finally died of recurrence in the liver. He gained one and three-fourths years of normal comfortable life.

NEUROLYSIS FOR CICATRICIAL STRANGULATION OF MUSCULOSPIRAL NERVE

DR. DEWITT STETTEN presented a man, age twenty-two years, who was first seen March 7, 1922. He had been working in a wire factory and on November 3, 1921, while operating a wire-winding machine, an accident occurred which resulted in the wire winding itself tightly around his right arm just above the elbow. The arm was not fractured nor was the skin even cut, but a deep furrow formed. For a few days he was not able to use the arm, but there was no immediate numbness or paralysis and he even returned to work about a month after the accident. Two months after the accident, on January 9, 1922, he first noticed a numbness of the thumb and the adjoining region of the dorsum of the hand, and two days later, on January 11, 1922, a wrist drop developed. The paralysis of the extensors of the wrist and proximal phalanges rapidly became complete and showed no tendency to improve. On March 4, 1922, he was examined by Dr. George W. Jacoby, who established the presence of a total musculospiral paralysis below the branch innervating the supinator longus with the characteristic motor and sensory paralyses and with reaction of degeneration present both on stimulating the muscles and nerve. Conditions of the paralyses were unchanged when he was seen by the reporter. There was absolutely no trace of active motion in the wrist, the extensor ossi metacarpi pollicis, or the proximal phalanges. There was a deep circumferential furrow about an inch above the right elbow, and at the point where this furrow crossed the musculospiral nerve there was a somewhat sensitive nodule. X-ray examination showed a faint line indicating the furrow in the soft parts, but there was no evidence of bony injury. Patient was operated on, March 13, 1922, under general anaesthesia. An incision was made along the outer edge of the biceps at the lower third of the arm, extending down the forearm. After the skin had been divided, a dense transverse scar was found. The biceps was pulled inward and the musculospiral nerve exposed above the scar area. The nerve was seen to run directly under the scar, which apparently bound the nerve tightly against the bone. The scar was gradually and carefully divided until the nerve was entirely free. It was found that a deep furrow had been made in the nerve by the compression of the scar and the proximal end of the nerve was slightly swollen. It was apparent that the nerve was not divided, but on palpation it was found that the nerve tissue had been seriously damaged by compression so that only rather a thin area was left between the proximal and distal portions. At the time it was assumed from the results of palpation that very few of the nerve fibres were left undamaged, and that the nerve was held together mainly by the sheath. The damaged area was below the point from which the branch of the supinator longus was given off, and when this branch was irritated by pinching with the forceps, there was a distinct contraction of the supinator longus. The wound was closed and the hand and wrist put up in a cock-up splint. Thirty-six hours after operation the patient was able to extend the wrist slightly. Within the next week there was very rapid improvement in extension of the wrist, and eleven days after operation, patient could not only extend the wrist rather well, but could also extend somewhat the extensor ossis metacarpi pollicis and the proximal phalanges, and the extensor muscles of the forearm began to react weakly to Faradism. The area of anaesthesia had not changed. Five weeks after

ENTERO-ENTEROSTOMY

operation the extension of the wrist and fingers was almost normal and the area of musculospiral anæsthesia had completely disappeared. About a month later the function of the extensors of the wrist, the thumb and the proximal phalanges of the fingers was practically normal, both as regards motion and power. All electrical reactions were likewise normal. The furrow above the elbow has persisted, but does not seem to cause any serious trouble except possibly slight weakness in the biceps.

This case shows the occurrence of a late musculospiral paralysis from compression of a cicatrix after only soft part injury. It is presented, however, mainly to illustrate that after a serious lesion of a nerve, with total paralysis and even reaction of degeneration almost immediate beginning recovery can take place after the cause of the nerve disturbance is removed. Most of the writers on injuries of the peripheral nerves admit this possibility. He thought it to be extremely doubtful if this can occur if there has been an actual division of the nerve, but that it can occur after a cicatricial strangulation is released by neurolysis is definitely illustrated by this case.

ENTERO-ENTEROSTOMY SEVEN YEARS AFTER GASTRO-ENTEROSTOMY

DR. DEWITT STETTEN presented a woman, age fifty-three years, who was first seen with Dr. Max Einhorn on May 20, 1926. The essential fact in her history was that she had been a sufferer from stomach trouble since her first pregnancy, twenty-eight years ago, with epigastric distress and occasional vomiting after meals. In 1903, she had a ventral suspension and appendectomy performed. She was under more or less constant treatment until April 8, 1919, when she was operated on in Chicago, presumably for a cicatricial benign stenosis. A posterior retrocolic gastro-enterostomy was performed. After the operation the patient evidently had a rather persistent vicious circle. She vomited for nine weeks and was given gastric lavage twice daily. After that she gradually began to improve, but never gained much in weight, her best weight for the next two years being ninety-seven pounds. She gained weight, thereafter, and went as high as 110 pounds about six months ago. She remained fairly well with only occasional attacks of indigestion and vomiting after a dietary indiscretion until January, 1924, when she had a very severe attack of acute right upper abdominal pain, lasting five hours, with vomiting. She became decidedly jaundiced and the urine was very dark. She also had a slight rise of temperature. This attack subsided after ten days, and for the past two years she has been fairly well except for occasional sensation of pressure in the upper abdomen after eating. Her present illness began May 10, 1926, with a slight attack of right upper abdominal pain. In the ten days before she was seen by Doctor Stetten, she had repeated attacks of pain in the right hypochondriac region varying in severity and lasting from one-half to five and a half hours. In some of the attacks the pain radiated to the back and shoulders and some were so severe that morphine was required. She became slightly jaundiced and vomited during the severer attacks.

The patient was a rather thin, undernourished woman. She was distinctly though slightly jaundiced. There was a solidly healed median hypogastric and long upper right rectus scar. There was distinct sensitiveness in the right hypochondrium and slight rigidity, definitely increased by deep inspiration. Temperature was normal. The leucocyte count was 17,800, with 90 per cent. polymorphonuclears. X-ray examination showed a distinct round, mottled shadow at the upper free border of the liver, suggesting a large thickened wall gall-bladder containing multiple calculi. Administration of tetra-iodo-

phenolphthalein showed no increase in the density of this shadow, indicative of an obstruction to the cystic duct.

With the diagnosis of subacute cholecystitis and cholelithiasis with multiple calculi in the gall-bladder and a calculus impacted in the cystic duct or at the junction of the ampulla of the gall-bladder and the cystic duct, operation was performed under general anaesthesia May 24, 1926. Through a long right hypochondriac incision through the rectus, a very large, tensely distended, much injected, purplish gall-bladder, fully the size of a large pear,

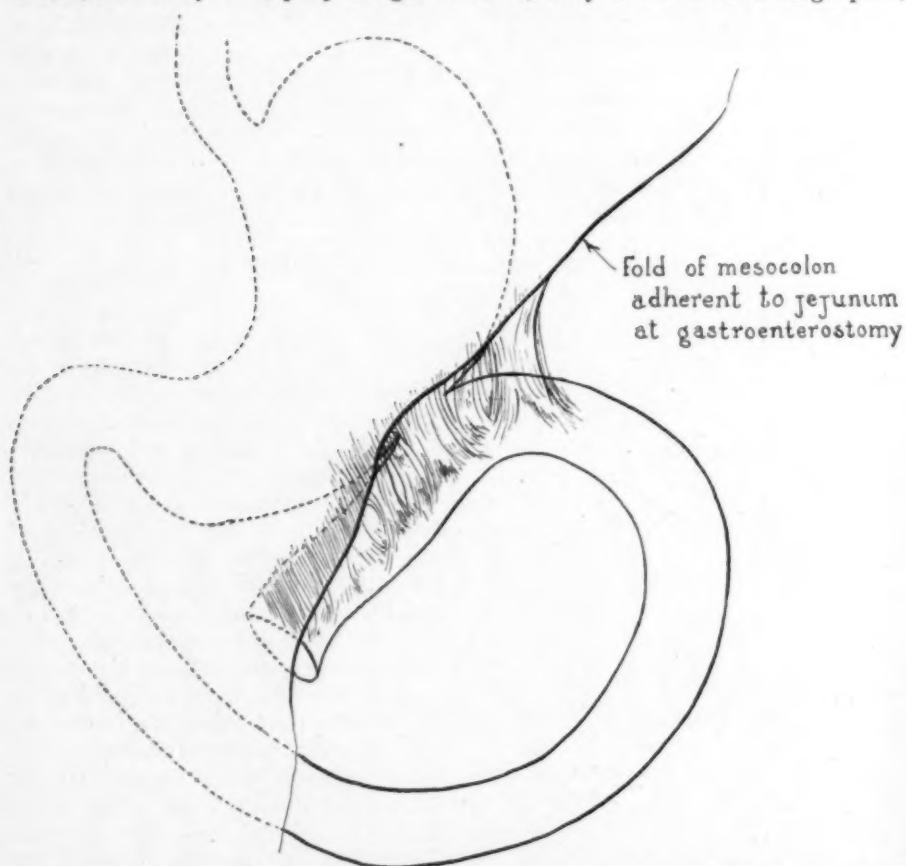


FIG. 2.—Diagram representing condition of gastro-enterostomy observed at gall-bladder operation with fold of mesocolon adherent to jejunum at gastro-enterostomy, particularly to efferent loop.

was exposed. There was a large calculus impacted at the junction of the ampulla of the gall-bladder with the cystic duct, and when this was milked upward and the gall-bladder tension somewhat diminished by expression, numerous calculi could be felt in the gall-bladder itself. No calculi could be felt in the common bile duct or at the papilla of Vater. A typical cholecystectomy from above downward was done and a double ligature applied to the cystic duct stump which was cauterized. There was no evidence of ulceration, cicatrization or tumor in the stomach, pylorus or duodenum. The pylorus was widely patent and the index finger could be easily invaginated into it from both the gastric and duodenal sides. The gastro-enterostomy was next examined, which was found to be of the posterior retrocolic type. The anastomosis had been made with a comparatively short loop running

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from left to right and was placed near the greater curvature of the stomach at about the junction of its middle with its pyloric third. The stoma was about one inch in diameter. The edges of the stoma could be felt distinctly. They were smooth and there was no evidence of ulcer, either in the stoma or in the jejunum. The mesocolon was adherent at the anastomosis, particularly at the beginning of the efferent loop, which seemed to be surrounded by a portion of the folded mesocolon (Fig. 2.) These adhesions around the gastro-enterostomy were partially separated, but only sufficiently to expose the anastomosis to thorough inspection and palpation and to establish the fact that the loop was running in the proper direction and not kinked. It was deemed inadvisable to make a complete exposure, particularly as the adhesions of the mesocolon surrounding the beginning of the efferent loop were rather vascular and inasmuch as it was felt that nothing was to be gained by entirely freeing the fold of mesocolon from the intestine. A cigarette drain was introduced past the cystic duct stump to Morison's pouch and the abdominal wall was closed in the usual fashion. The gall-bladder showed the characteristic changes of a subacute cholecystitis, which was confirmed by microscopical examination. It contained a large quantity of thin, somewhat turbid, yellowish-brown, biliary fluid, and twenty-five fair-sized, angular, faceted, dark blackish-brown, rather friable calculi, varying in size from a pea to a hazelnut kernel and numerous small black particles, either pieces of larger or newly formed smaller calculi. The cystic duct was quite narrow, barely admitting the passage of a probe.

The patient showed rather more than usual shock from the relatively simple operation. She had the usual post-operative vomiting which ceased after thirty-six hours, when she also began to react very satisfactorily as regards her general condition. On the fifth day she had a good result from an enema. On the sixth day she seemed to be making a very satisfactory convalescence except that she belched a good deal and complained of some gastric distress. In the evening of that day she was very nauseated and began to vomit biliary fluid. In spite of frequent lavage, which showed extreme retention, this vomiting or darker biliary fluid plus practically everything ingested, persisted, and June 4, 1926, a consultation was held with Dr. Max Einhorn and Dr. Joseph A. Blake, when it was agreed that the patient was probably suffering from a recurrence of a vicious circle due to some disturbance at the old gastro-enterostomy. Observation was agreed upon and the usual measures for counteracting the dehydration were instituted. Several unsuccessful attempts were made to feed her by means of the duodenal tube. Marked acetoneuria developed. An indefinite sensitive resistance could be felt in the lower epigastric and left hypochondriac regions. Three further consultations were held and although the patient had a few bowel movements, her vomiting persisted, and on June 7, 1926, two weeks after the cholecystectomy, reoperation was decided upon. In spite of the incessant vomiting her condition had remained very fair, but, nevertheless, a transfusion of blood was given as a precautionary and preparatory measure. While the patient was being scrubbed up on the table, for the first time definite visible gastric peristalsis was noted. Under a light general anaesthesia a longitudinal median epigastric laparotomy was made. An enormously dilated stomach, including the first portion of the duodenum, and with an obviously patent pylorus, was seen. The stomach filled the entire upper two-thirds of the abdomen. The stomach wall was congested and hypertrophied. A dense longitudinal band of adhesions of the duodenum, colon and omentum to the right hypochondriac scar closed off the site of the cholecystectomy. There was a slight fibrous exudate on the transverse colon. It was imme-

diately seen that nothing could be done without emptying the stomach, and a longitudinal gastrotomy incision was made in the anterior wall in the pre-pyloric region. Some air escaped immediately and about one thousand c.c. of thin biliary fluid containing milk curds was aspirated from the stomach and duodenum. The stomach now collapsed completely and the gastrotomy wound was closed in the usual fashion. The transverse colon could now be lifted up. The transverse mesocolon was densely infiltrated, shrunk and tightly plastered by dense adhesions to the region of the gastro-enterostomy

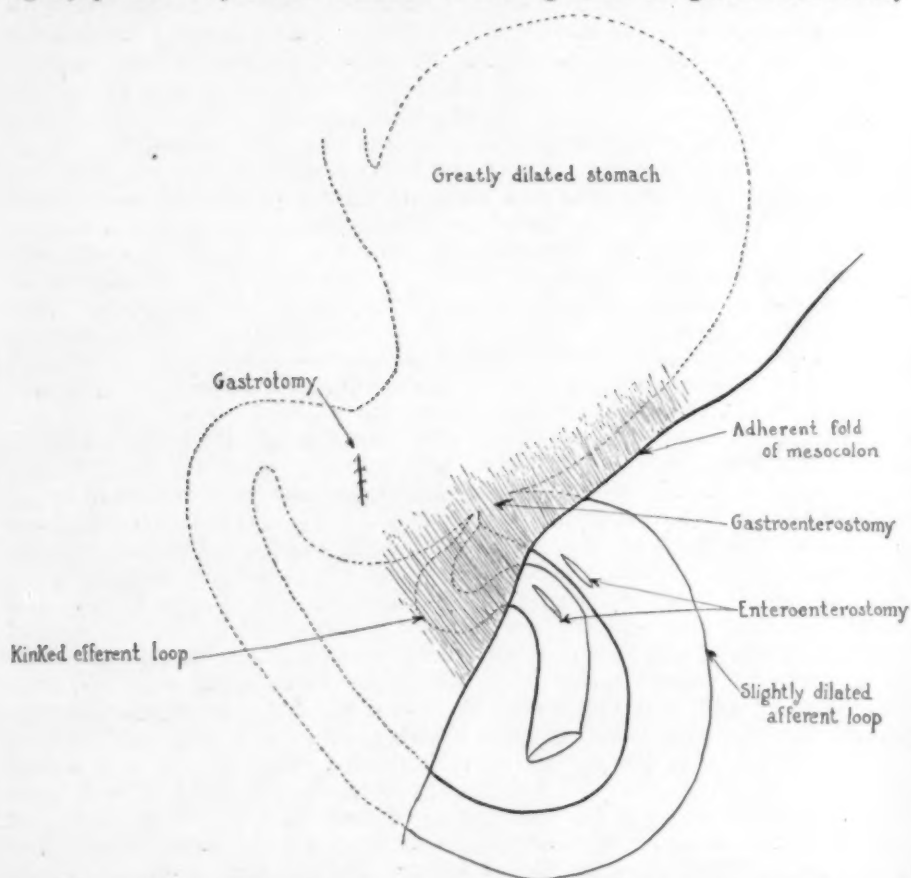


FIG. 3.—Diagram representing condition found at second operation showing greatly dilated stomach and fold of mesocolon densely adherent below gastro-enterostomy with some dilatation of afferent loop and marked kinking of efferent loop. Location of gastrotomy and entero-enterostomy indicated.

but considerably lower down than at the first operation. Emerging from underneath the edge of the fold of transverse mesocolon were two definite intestinal loops running more or less parallel in the long axis of the body. The one lying to the left was somewhat dilated and friable and seemed to be the proximal loop of the gastro-enterostomy, apparently somewhat shorter than appeared at the previous operation. The right loop was somewhat smaller than the left but not actually collapsed. It ran downward and to the right and was apparently the efferent loop of the anastomosis. It was felt that separation of the adhesions and direct exposure of the gastro-enterostomy would be an inadvisable procedure, and a lateral entero-enterostomy between these two loops was decided upon. This was proceeded

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with by suture. When the intestinal loops were opened it was seen that the left loop contained thin biliary fluid similar in character to that which had been previously aspirated from the stomach, and that the right loop was empty, proving that we were dealing with the correct loops of the gastro-enterostomy. A finger inserted into the left loop entered the stomach about one inch and a half above the edge of the adherent mesocolic fold. The gastro-enterostomy opening seemed to be somewhat narrower than had been assumed at the previous operation, just admitting the tip of the examining finger. With the finger in the afferent loop no connection with the efferent loop could be felt. Inserting the finger into the right loop a definite angulation could be recognized which turned toward the gastro-enterostomy opening, but the gut was so kinked off that the finger could not actually be inserted into the stomach from the right loop (Fig. 3). The entero-enterostomy was completed in the usual manner, leaving a very satisfactory anastomosis about one inch in diameter, and the abdominal wall was closed in the customary fashion. The operation was very well borne by the patient and the usual methods of stimulation and fluid administration were instituted. Eighteen hours after the operation the patient presented a most satisfactory appearance. She had not vomited since the operation and her nausea had completely disappeared. She was quite cheerful and already gave the impression that she was on the road to recovery. Aside from small superficial abscesses developing in both the right hypochondriac and median epigastric wound, which healed promptly after evacuation, her convalescence was entirely uneventful. For a short time there was some biliary drainage from the gall-bladder wound. She took gradually increasing quantities of nourishment and never vomited again. Since her discharge from the hospital she has been eating practically everything, gaining steadily in weight, and aside from occasional flatulence after a dietary indiscretion, she is entirely free from abdominal pain or gastric symptoms. In fact, her stomach condition is much better at the present time than it has been in the past twenty-eight years, and she now weighs 116 pounds, which is five pounds heavier than her best weight in that period.

This case is presented primarily to demonstrate the possible menace of a gastro-enterostomy to a patient who is subjected to a subsequent laparotomy, particularly if that gastro-enterostomy has been performed primarily without proper indications, and if some defect in the position or formation of the anastomosis renders it susceptible to a recurrence of trouble. As regards this woman, it is possible that her original symptoms were largely the result of her gall-bladder pathology which, according to her history, probably began, as so frequently happens, during or just after her first pregnancy, and that the gastro-enterostomy performed seven years ago was never really indicated. Of course it might be argued that if the gastro-enterostomy had never been inspected at the gall-bladder operation, the dense adhesions with the kinking of the efferent loop might never have developed, but having the abdomen open, it was not only a pardonable but even a justifiable curiosity which prompted the examination of the pylorus and the gastro-enterostomy to determine their present status.

DR. JOHN DOUGLAS said that he had encountered just such a condition as a post-operative complication, in which there was a mechanical kinking or narrowing of the distal loop due to adhesions, in which case an entero-enterostomy had not availed to relieve the symptoms as in Doctor Stetten's patient. If the obstruction is in the proximal limb, the entero-anastomosis drains the duodenal contents into the distal intestine. When, however, it is

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proximal to the stomach stoma, although the duodenal contents may drain into the proximal limb after entero-anastomosis, the stomach contents emptying through the stomach stoma must pass for some distance along the proximal limb against the normal peristaltic wave before entering the distal intestine. This seemed to him the reason why the entero-anastomosis had failed in his own case, and made it difficult for him to understand the mechanics in Doctor Stetten's case, unless the stomach contents in the latter were leaving the stomach through the pylorus and not the stoma.

DOCTOR STETTEN, in closing, insisted that the examination of the former gastro-enterostomy was not only justified, but indicated. Suppose that this had not been done and he had missed a possible gastro-jejunal ulcer, would he not have been in a very embarrassing position if the patient, a few months later, suddenly had a severe gastric or intestinal hemorrhage? When one is so close to a gastro-enterostomy in the course of an abdominal operation, and there is no active infection present, the gastro-enterostomy ought to be examined to determine its present condition. It is his custom in all abdominal operations to make a general survey of the abdominal cavity and especially at all re-operations to examine the site of a previous operation to determine the existing status, unless there are special difficulties or definite contraindications, and he is of the opinion that most surgeons feel the same way on this subject. In fact, he is rather inclined to believe that not to make such an examination might easily be regarded as surgical negligence if a lesion of importance is overlooked. Possibly if the gastro-enterostomy had not been examined, the subsequent trouble might not have developed, but even this is by no means certain. The idea of disconnecting the gastro-enterostomy when he found the pylorus patent did occur to Doctor Stetten, but owing to the fact that the woman had a subacute condition of the gall-bladder, he did not feel that a detachment of the gastro-enterostomy was justified at the time, especially as the entire loop was rather adherent, and the adhesions to the efferent limb were particularly vascular, so that the operation would have been rather difficult. As pointed out, the simple cholecystectomy itself produced quite a post-operative shock. If a disconnection of the gastro-enterostomy had been attempted, it is very questionable if the patient would have stood it.

EXTRUSION OF INGESTED FISH BONE AT UMBILICAL REGION

DR. DEWITT STETTEN presented a woman, aged fifty-nine, first seen by him on April 15, 1924, with a history that for about three and a half months she had noticed a swelling to the left of her umbilicus which had not enlarged, but which had become somewhat sensitive. On examination, a round, semi-fluctuating, subcutaneous nodule about three-quarters of an inch in diameter was found at the left of the umbilicus. This nodule was adherent to the skin, which was reddened and oedematous. At the most prominent part of the nodule was a minute dark spot in the skin, suggesting the head of a comedo. The nodule looked inflammatory, but the possibility of a metastasis from an intra-abdominal neoplasm was considered, although there was no evidence of any abdominal or pelvic tumor. The nodule was excised by

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an elliptical incision which circumscribed the nodule. When it was freed from the fascia it was found that protruding forward from the abdominal cavity, and entering the nodule, was a fish bone which was easily withdrawn. The nodule consisted of a mass of skin and inflammatory subcutaneous tissue in the centre of which was found some thick inspissated pus. The foreign body was a thin, flat, flexible, cartilaginous structure about one and a half inches in length and undoubtedly a fish bone. The fish bone had penetrated to just beneath the cutis, the minute dark spot in the skin corresponding to the end (Fig. 4). On questioning the patient after the operation, she

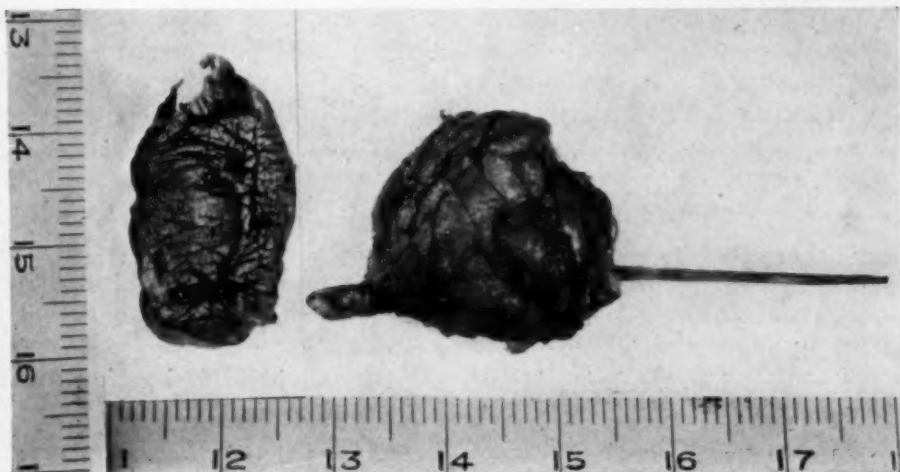


FIG. 4.—Anterior and lateral photographic view of excised specimen of extrusion of ingested fish bone at umbilical region. In the anterior view (left) the dark spot in the skin where the fish bone is almost penetrating can be seen, and in the lateral view (right) the fish bone is seen piercing through the inflammatory mass of subcutaneous tissue.

stated that about a year before a fish bone had become caught in the pharynx which she had some difficulty in swallowing but which finally passed into the stomach. About three months after this she had an acute abdominal attack with pain around the navel and with nausea but no vomiting. She was in bed for three days and had quite some tympanitis. At the time she was treated by local applications. After that she had no further trouble until the nodule developed some six months later. This history apparently accounted for the subsequent development of the case and the curious findings.

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DRS. CARL G. BURDICK and BRADLEY L. COLEY presented a paper with the above title, for which see page 867, ANNALS OF SURGERY, vol. lxxxiv.

DR. WILLIAM B. COLEY said that the paper presented covered the largest number of cases that has ever been published from a single hospital; and an analysis of the methods and results should be of value to the profession at large. But there does not seem to be any advantage in making the distinction of maldescended testis and ectopia, as the present writers have done. The word *ectopia*, derived from the Greek word meaning "out of place" or "mal placed," has so long been used to cover all varieties of undescended or maldescended testis that there is no good reason for giving it a different interpretation and limiting it to a certain variety of misplaced testis.

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The speaker became interested in this subject many years ago, and in April, 1908, before the New York Surgical Society, read a paper on "The Treatment of the Undescended or Maldescended Testis Associated with Inguinal Hernia" (ANNALS OF SURGERY, September, 1908) reporting at that time 128 cases upon which he, personally, had operated. Unlike the series of cases reported this evening, his series included adults as well as children. Of the 128 cases then reported, eighty-four were in children under the age of fifteen years, and forty-four were in adults ranging in age from sixteen to forty-five years. In this paper he called attention to the wide variance of opinion as to the etiology of the condition, the indications for surgical treatment, and the best methods of operation. One of the great difficulties in determining the best method of operation is the fact that there are so few statistics giving the end results of the different methods employed in a large series of cases.

As stated in his paper, it is possible to divide these cases into two main groups, namely, the undescended and the maldescended testis. As regards the first group, if, in its downward progress, the testis is stopped before it enters the inguinal canal, it is called abdominal ectopia; if it is stopped within the inguinal canal, it is called inguinal ectopia, if it passes outward to the external canal into the region of the upper scrotum, it is called pubic ectopia. In the second group, properly designated as maldescended testis, the testis occupies some abnormal position, *e.g.*, the perineum, Scarpa's triangle, or the aponeurosis of the external oblique, in the region of the anterior superior spine. It seems wise to retain the general term *ectopia* to include all of these varieties.

In regard to the cause of these different types of ectopia, the view expressed by Curling in 1857, that the principal and almost only agent connected with the descent of the testis was the gubernaculum, received the support of most surgeons up until comparatively recent times. Godard accepted the theory fully and believed nothing more simple than this explanation—no gubernaculum and the testis remains within the abdomen; no middle fasciculus, and inguinal ectopia occurs, while in the event of the anomalous insertion of the fasciculus either in Scarpa's triangle or the ischium, we have cruroscrotal and perineal ectopia. As late as 1887, Lockwood, after a most careful anatomical study of the undescended testis, concluded that the gubernaculum was the main factor in the descent of the testes, and he attributed the various types of maldescent to overdevelopment of portions of the gubernaculum lying in these particular regions. However, later, Sébilleau, who also made an extensive research, concluded that "perineal ectopia is a purely congenital affair. It depends neither upon pathological nor anatomical causes and least of all upon the gubernaculum."

On the clinical side, Championniere, who had an unusually large experience in hernia, strongly opposed the theory of the gubernaculum origin of the undescended testis. He held that only a physiology as legendary as that which, in former times, accepted multiple testes as proven facts, could seek

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to explain the descent of the testis by a legendary origin of the gubernaculum testis.

The latest authoritative opinion, supported most recently by Sir. John Bland-Sutton, is, that the condition is not definitely due to any of the causes mentioned but is a congenital defect, the exact nature of which very little is known.

In regard to the comparative frequency of the undescended testis in children and in adults, I made a study of the statistics of the Hospital for Ruptured and Crippled covering a period from 1890 to 1908, and of 59,235 cases of inguinal hernia in the male showed that of 739 cases of undescended testis, 561 occurred in 18,410 children under the age of fourteen years, or 3 per cent.; while only ninety-two cases occurred in 3848 between the ages of fourteen and twenty-one years, or 2.2 per cent.; and only seventy-five cases in 37,370 over twenty-one years of age, or .2 per cent. In other words, the undescended testis is fifteen times more frequent under the age of fourteen years than after the age of twenty-one years.

There is still a great difference of opinion on the question of whether the undescended testis is more likely to become malignant than the normally placed testicle. In a paper on "Cancer of the Testis," read before the Southern Surgical and Gynæcological Association in December, 1914 (*ANNALS OF SURGERY*, July, 1915), Doctor Coley reported a series of sixty-four cases of malignant disease of the testis personally observed, in which, in twelve cases the disease occurred in the undescended testis. At the Hospital for Ruptured and Crippled, from 1890 to 1907, in 59,235 cases of inguinal hernia in the male sex, there were found 737 cases of undescended testis, without a single case of sarcoma of the undescended testis. Such statistics as these, however, do not give a fair estimate of the relative proportion of cases of sarcoma of the undescended testis, inasmuch as many of these cases, particularly those of abdominal ectopia, will seek relief at some general hospital rather than go to a hospital devoted specially to the treatment of hernia. The only way of determining the relative frequency of sarcoma of the undescended testis is to study a consecutive series of sarcomas of the testis. In his first twenty-five cases of sarcoma of the testis there was not a single undescended testis. On going over his entire statistics he found that in sixty-four cases of sarcoma of the testis, the disease occurred in the undescended testis in twelve cases. Odiorne and Simmons, in a review of fifty-four cases of malignant disease of the testis, observed at the Massachusetts General Hospital, found 6, or 11 per cent., in which the disease occurred in the undescended testis. An analysis of the cases observed by Chevassu, Odiorne and Simmons, and at the Presbyterian Hospital up to the end of 1914, shows the proportion as one to five. Doctor Coley's statistics show almost the same proportion, or about one to five and one-half. If, then, there are only 737 cases of undescended testis in 59,235 consecutive cases of inguinal hernia, and twelve cases of sarcoma of the undescended testis in sixty-four cases of sarcoma of the testis, one at once sees that the unde-

scended testis is more prone to sarcomatous degeneration than the normally placed testis. However, the number of cases encountered is so very small that it should not be given too much weight in the discussion of the treatment. In 1904, Doctor Coley operated upon a boy of fourteen years of age, for a left oblique inguinal hernia associated with undescended testis. Last month, or twenty-two years later, this same patient came to see him in a state of great anxiety because his physician had told him that the testis should be removed in order to avoid the risk of its becoming the seat of malignant disease. Examination at this recent date showed the testis to be small and atrophied, and placed just outside of the external ring. It would seem, therefore, that the pendulum has swung far, perhaps too far, in the opposite direction; and the view once held that the undescended testis is never the seat of malignancy has been changed so that now many physicians even exaggerate the risk to their patients.

As regards the method of operation, the method which Doctor Coley has employed is practically the same as that already described by Doctor Burdick and Dr. Bradley Coley. A very advantageous step recommended by Doctor Bevan, of Chicago, is the employment of a circular suture of chromic catgut which is passed just outside the external ring so as to include the deep and superficial fascia which, when tied, prevents any possibility of the testis retracting beyond the external ring into the canal or above the surface of the aponeurosis.

In 1908, attention was called to Keeley's operation of burying the testicle in the tissues of the upper thigh and later transplanting it into the scrotum in a second operation. We have never used this method in the Hospital for Ruptured and Crippled, believing that if one could free the cord sufficiently to enable one to place it in the thigh, it would be quite as easy and as satisfactory to place it in the scrotum at once, thus avoiding a second operation. More recently Torek has reviewed this method and modified it slightly, and a year ago Herbert Willy Meyer reported a considerable number of cases treated by this method with very good results. As far as I know, no very large number have been reported with a follow-up for a considerable period.

In the early series of cases already referred to, covering 128 operations, twenty-five represented an ectopia of the inguino-superficial type, in which the testis and sac rested upon the aponeurosis of the external oblique. There were nine cases of the inguino-perineal type, the sac and testis occupying the perineal region. In not a single case was there a recurrence, and in only two cases was the testicle sacrificed.

It is interesting to note that a somewhat larger proportion of the cases reported in his series was followed for a considerable period of time than it was found possible to do in a much larger series of cases more recently observed at the Hospital for Ruptured and Crippled. Of the 128 cases operated upon, seventy-two were traced from one to fifteen years; fifty-two children were traced from one to fifteen years, seventeen less than one year, and fifteen were not traced; of the forty-four adults, nineteen were traced

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from one to ten years, four were traced less than one year, and twenty-one were not traced. Of nineteen adults examined from one to ten years after operation, the testis was found in good position in the scrotum in eight cases and at the external ring, or not stated, in the others. One case worthy of special note is that of a man, aged twenty-five years, who was operated upon five years previous, for right undescended testis of the inguinal type. The testis was brought into the scrotum and was in good position at the time of my report, five years later. Prior to the operation, this patient had been subject to epileptiform seizures occurring often within one to two weeks. After the operation these attacks ceased entirely.

In comparing the cases of adults with those of children, it was found that the testis showed a greater tendency to remain in the scrotum in adults than in children.

Broca, in 1902, reported, 138 cases of inguinal ectopia in children and sixty-two patients with seventy-nine operations beyond one year; thirty-one perfect results; thirty-five fairly good results and no recurrence of hernia.

While it is generally recognized that the undescended testis is of no functional value and that a person with a bilateral undescended testis is sterile, it is interesting to note that a patient who, at the age of thirty years, was operated upon in 1895 by Doctor Schoonmaker, of Yonkers, and in 1910 by Doctor Coley, was married in 1902 and had a child born in April, 1903. This is the second case that he had been able to find in which a patient, suffering from double undescended testicle, had become a father.

DR. SEWARD ERDMAN said that recently, Mixter, of Boston, had reported the end results in 107 cases, which had been carefully followed, and found the testes in the lower scrotum in only 42 per cent., which corresponds very closely with the 40 per cent. in the series of Doctors Burdick and Coley.

In both of these reports, the authors have classed as satisfactory end results about twenty to thirty per cent. more, because in this number the testis was found in the upper part of the scrotum. However, Doctor Burdick, in his paper, mentions the classical forms of non-descent of the testis; viz., the abdominal, the inguinal, the pubic, and the upper scrotal types. If the position of the testis after operation is upper scrotal, it is still to be regarded as in a minor degree nondescended, and such a result cannot be regarded as entirely satisfactory. From these excellent follow-up reports, therefore, it will be seen that the Bevan operation only gave entirely satisfactory results, as regards position of the testis, in from 40 to 42 per cent.

Furthermore, by too many operators the Bevan operation is believed to include the routine division of the spermatic vessels, which must be strongly condemned as a procedure leading to atrophy of the testis in over 85 per cent. of the cases, in Mixter's series. Indeed, Bevan himself once said that he only had to employ this section of the vessels in about 10 per cent. of operations. Certainly, there is no logical reason to expect the already handicapped and usually undersized testis to thrive better after dividing the spermatic vessels which represent most of its blood supply.

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DOCTOR ERDMAN expressed his belief that the so-called retraction of the testis, after replacement in the scrotum at operation, is more often due to contraction of the undeveloped scrotum. For even if at operation the scrotum be forcibly stretched to sufficient dimensions, there is no guarantee that the dartos will not regain its tone and again contract the scrotal sac and elevate the testis. Especially in cases of bilateral non-descent, the scrotum is so rudimentary that it is almost impossible to obtain a satisfactory result by the Bevan operation.

In all cases of rudimentary scrotum, the Torek operation is the method of choice because its chief asset is the development of a larger scrotal sac during the period over which the scrotum is attached to the thigh. The cases shown before the Section of Surgery of the Academy, last January, by Franz Torek, Carl Eggers and Herbert Willy Meyer were ideal end results attained by the Torek operation.

DR. FRANZ TOREK did not think that a testicle in the upper part of the scrotum could be considered a satisfactory result and there were only 114 cases in this series of 537 in the scrotum. As it is not stated whether they were in the middle or lower part, we may assume that some of these 114 were not in the bottom of the scrotum. Personally, he only considered a result perfect if the testicle was in its normal position at the bottom of the scrotum. He had proven that the operation of orcheopexy, the technic of which he had described in 1909 and a number of cases of which had been shown at a meeting of the Surgical Section last January, uniformly gave the result that the testicle hung in the bottom of the scrotum, and most surgeons would prefer the chance of a 100 per cent. result rather than 114 out of 537. Of course it required a double operation, as Dr. William Coley said, but many would probably prefer achieving a perfect result even at the expense of two operations instead of one. As regarded the division of the vessels, Doctor Torek had never considered this a proper procedure. The vessels are often very short, but if they are prepared off to a considerable height and divested of all coats, they can be brought down. One of the advantages of the operation he called orcheopexy was that by it the scrotum is lengthened and after the first few months there is no possibility that contraction of the scrotum may drive the testicle back. That is a not unimportant part of the operation.

DR. EDWARD W. PETERSON said he had had the privilege of working with Doctor Torek at the Post-Graduate Hospital, and he agreed with those speakers who said it was not necessary to attach the scrotum to the thigh fascia to get sufficient lengthening. If the cord can be sufficiently lengthened, there is no trouble in keeping the testicle down in the scrotum. By systematic stretching of the scrotum before operation, one can soon develop sufficient size and length in this structure, even where it is rudimentary in the beginning.

DR. JOSEPH P. HOGUET said he did not believe that in every case where there had been division of the vessels an atrophy resulted because he remem-

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bered a number of cases where the testicle was absolutely normal as to size and mobility in the bottom of the scrotum after division of all the vessels. By the division of a certain number of vessels, in the majority of cases the testicle can be brought down. There were two points he wished to emphasize in regard to the technic. Doctor Burdick said the important thing was to get the testicle actually in the scrotum. It is not realized how easily it can be put in Scarpa's triangle and the scrotum should be uncovered so the testicle can be seen to be there. In regard to closing the lower cut end of the tunica vaginalis, the speaker formerly closed them all with the result that he had an occasional hydrocele. Since he stopped this practice hydrocele has not occurred.

DR. ALEXIS V. MOSCHCOWITZ stated that in justice to Doctor Bevan, it is only proper to say that Doctor Bevan advised the division of the spermatic vessels only in those cases in which the testicle could not be brought down into the scrotum after extensive mobilization.

Some years ago, Doctor Moschcowitz was an ardent advocate of what may be termed the extreme Bevan operation, and he published a paper on the subject, in which he described really beautiful results. Unfortunately, this paper was published after too brief a period of observation. A few years ago, Doctor Moschcowitz decided to reexamine these cases. While it is true that in an occasional case the result was excellent, in the great majority of the cases the result was exceedingly poor; in other words, the testicle had disappeared by absorption.

Since that time, Doctor Moschcowitz has never again divided the spermatic vessels and he wished to retract his previous recommendation of the extensive Bevan operation.

DOCTOR MOSCHCOWITZ has found that the important matter in operating on cases of cryptorchism is to mobilize the testes completely if necessary by liberating the spermatic vessels in the retroperitoneal space and when that has been accomplished, the testes can be supplanted into the scrotum without any difficulty.

DR. BRADLEY L. COLEY emphasized the following points: The first was in regard to the importance of the fascial layers. It is not as difficult as it might seem to misplace the testicle. He had seen several such cases. One of the speakers had emphasized the importance of elongating the scrotum, making up for a deficiency in the scrotum by a plastic operation (Torek operation) on the thigh. Undescended testicle operations, in the speaker's experience, had failed because of the shortness of the cord and not because the scrotum was small. Any operation that lengthens the cord sufficiently for the testicle to lie without tension in the bottom of the scrotum may be considered successful; but any other operation that fails to accomplish this must be judged a failure. The operation that accomplishes this desideratum with the least disturbance to the structures involved may be looked upon as the operation of choice.

DOCTOR BURDICK (in closing) said in reply to Doctor Coley's criticism of

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the terms maldescent and nondescent, he had tried to make a distinction between a testicle arrested along the path of normal descent and one which had descended into an abnormal position. As far as practice is concerned, it is almost always easy to bring down into the scrotum a testicle in an abnormal position because the cord is usually of sufficient length. As far as the gubernaculum is concerned, while it seems to have a definite influence on maldescent into the thigh, on the other hand it has never been proven satisfactorily that it had any influence in the inguino-superficial type.

As regards the perineal type of undescended testicle, personally the speaker had never seen a case. In cases called to his attention by others as being of the perineal type, he had proven they were not in the perineum, but in the thigh.

Doctor Burdick agreed with Doctor Coley as to the time of operation; the longer one can put off the time of operation the more chance the testicle has to descend normally.

In reply to Doctor Erdman, Doctor Burdick thought there was a good deal in what he said about the undeveloped scrotum and he also believes there is a great deal to be accomplished by Doctor Torek's operation. Nobody could refrain from admiration of the result in the cases shown last winter. Doctor Torek had claimed that his was not a traction operation. In cases where the scrotum is very much undeveloped an operation of that type is indicated. In suitable cases, where the scrotum is more normally developed the operation the speaker had described he believed to be better.

As to Doctor Moschcowitz remarks, Doctor Burdick thought that when the testicle was in the abdominal cavity it was necessary to divide the vessels before one could get the testicle down; if that is to be done, the decision to do this must be arrived at fairly early. The speaker had seen one or two cases where the testicle had sloughed; caused probably by making too great an attempt to divide all the fascial bands and thus injuring the tiny artery which accompanied the vas.

As to the importance of the fascial planes, he had seen the testicle placed in the wrong fascial layer time and time again during a period of twelve years, and a large number of experienced operators had made this same mistake.

BRIEF COMMUNICATIONS

THE SKIN FLAP METHOD OF COLOSTOMY

LAST January I reported a method in which a skin flap cover was utilized to surround the projecting intestine.* In this connection it was pointed out that in any of the old type of colostomies the opening was on the same plane with the skin of the abdominal wall. The colostomy cup had no means of anchoring itself at the artificial anus allowing the free escape of fecal contents. The work was altogether experimental. Since the last report I have been able to do this form of colostomy on two patients. One is now convalescing and his case will be reported at a later date. In the following case, a

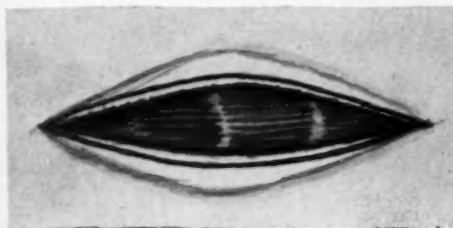


FIG. 1.—Initial skin incision.

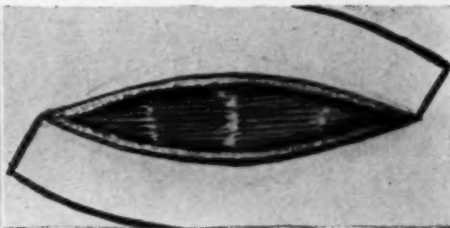


FIG. 2.—Additional incisions to form skin flaps.

colostomy was performed in the manner described, only the skin flaps were fastened somewhat differently.

Mr. Wm. B., aged fifty-nine, was admitted to the Emanuel Hospital, July 2, 1926. He came to my office complaining of cramps in the abdomen and prolonged spells of constipation. The cramps came on periodically and were relieved by cathartics; lately, even cathartics did not seem to bring any relief. During January, 1926, the patient noticed that he had a great deal of aching in the epigastrium; at approximately the same time he also observed two or three masses, each one the size of a walnut, in the left inguinal region. He consulted a physician who removed these glands and told him it was a "fibrous growth". In the last few days he noticed a large mass in the left side of the abdomen.

The physical examination revealed a well built, fairly well nourished individual. There was a lobulated mass about twelve centimetres in diameter situated in the left side of the abdomen, about the level and also below the umbilicus. The tumor itself could not be removed but the skin over the tumor was quite movable. There was no tenderness experienced on pressure. An operative scar about ten centimetres long was found in the left inguinal region.

The urine contained a trace of albumin. The hæmoglobin was 72 per cent. with a normal amount of erythrocytes and leucocytes. The Wassermann test was negative.

An exploratory incision, about ten centimetres long, was made in the left rectus muscle; the point of the umbilicus dividing the incision into two equal parts. On the left side of the spinal column, about the level of the twelfth dorsal vertebra and spreading down into the pelvis, there was a lobulated bleeding mass occupying the retroperitoneal space and pressing upon the pelvic colon. The tumor mass was fixed. No evidences of metastatic spreading was found. The sigmoid colon was brought to the outside; the peritoneal covering of the external surface of the sigmoid mesentery was incised in

* Steinberg, Moses E.: A Skin Flap Cover for Projecting Intestine. *ANNALS OF SURGERY*, January, 1926, vol. lxxxiii, p. 126.

BRIEF COMMUNICATIONS

order to freely mobilize the gut. The bowel was divided in an aseptic manner. The distal loop was inverted by a purse-string suture and dropped into the abdomen. About seven centimetres of the proximal loop of the sigmoid was brought out above the level of the skin and surrounded by skin flaps as depicted in the accompanying illustrations. (Figs. 1 to 5.) It is to be noted that the skin flaps are fashioned in a different manner than

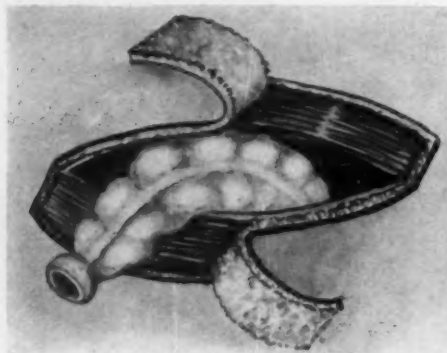


FIG. 3.—Skin flaps dissected and bowel delivered.

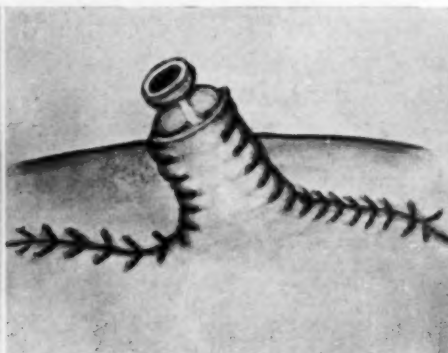


FIG. 4.—Projecting bowels covered by skin flaps.

suggested previously. It was not necessary to incise or undermine the skin in order to facilitate the approximation of its edges after the flaps were made. The bowel was opened by means of a cautery on the third day and the mucosa was sutured to the skin.

The post-operative recovery was rather stormy; the patient developed a paralytic type of ileus which was relieved by enemata injected through the colostomy opening.



FIG. 5.—Appearance of skin flap colostomy four months after operation.

It has been nearly four months since the colostomy was performed. All the structures concerned in the performing of this colostomy, the skin flaps, and mucosa of the bowel, have a healthy appearance. The patient carries a colostomy cup which is cleaned only one or twice a day. The feces escape directly into the cup and there is no soiling of the skin about the artificial anus.

MOSES E. STEINBERG, M.D.,
Portland, Oregon.

NONUNION OF THE HIP

In a communication in the *ANNALS OF SURGERY*, October, 1926, Dr. Royal Whitman commented on my paper "Ununited Fractures of the Hip." In effect, he asserted that my description, by illustration, of the Brackett operation was inaccurate. I grant that if one adheres strictly to the technic as described by Brackett in 1917, this illustration is inaccurate, but the operation depicted is in basic principle similar to Brackett's.

NONUNION OF THE HIP

Inasmuch as Brackett's operation had as its object the revascularization of the head and consequent union with the reconstructed upper end of the femur, we have fallen into the habit in the Mayo Clinic of calling any attempt of this kind a Brackett type of operation. Although we have used a somewhat different technic from Doctor Brackett, because we felt that the nourishment to the head must come from the spongy bone of the trochanteric region rather than from any blood supply brought in through the muscles and portion of the trochanter that he reimplanted, I felt that for descriptive purposes, Brackett's name should be used.

My conception of the essential feature of the underlying principle of the Brackett type of operation is exposure of the fracture area, freshening of the head and remodelling of the upper end of the femur to bring spongy bone, rich in bone-forming properties, in contact with the head and thus to secure union and skeletal support. My conception of the essential feature of the Whitman type of operation is excision of the head and insertion of the remodelled upper end of the femur into the acetabulum for skeletal support. Both operations shorten the portion of the femur between the proximal end of the distal fragment and the trochanteric area.

The raising of the trochanter in whole or in part with the attached muscles has been practiced for many years to expose the hip-joint. Doctor Whitman has forcibly called to our attention the value of fastening it at a lower level on the shaft of the femur, but, when he states that this step is the essential feature of his reconstruction operation, it appears to me that, important though this step may be, it is overestimated. His object in this operation is to get skeletal support. It is obtained by placing the remodelled upper end of the femur in the socket and not by transferring the trochanter to a lower level on the shaft.

I agree with Doctor Whitman that, if there is extensive absorption of the neck of the femur, his operation is the method of choice, except in the case of young persons for whom I believe the Brackett operation, or a modification of it, will give better results. There is at present a tendency to disparage the bone-grafting operation popularized largely by Albee many years ago. Because this operation has failed in unsuitable cases does not mean that it should fall into disuse. Undoubtedly the operations mentioned all have their place, and while Doctor Whitman is to be congratulated on the development of a very successful operation for cases suited to it, I am quite sure he will agree that it should be confined to those cases in which there is no reasonable chance of effecting anatomic restitution by means of the bone-graft. With his statement that the bone-pegging operation offers but slight advantage over the results obtained by the Whitman reconstruction operation, I cannot agree, basing my opinion on the results obtained in our operative cases; a good proportion of our bone-pegging operations have resulted in practically normal hips.

MELVIN S. HENDERSON, M.D.,
Rochester, Minn.

BRIEF COMMUNICATIONS

NECK PAIN IN SUBPHRENIC ABSCESS

The importance of neck pain in the diagnosis of subphrenic abscess has been given but scant attention by surgeons and others. Of recent writers on this subject, Dexter¹ seems to be the only one who definitely mentions it. A diagnostic sign of such great value should be given greater prominence.

In 1922, Capps and Coleman² carried out a series of ingenious experiments to determine the localization of pain from stimulation of the parietal and diaphragmatic peritoneum. A trocar was passed through the abdominal wall and through this, in turn, was passed a long silver wire to various parts of the parietal and diaphragmatic peritoneum. Patients having ascites or individuals who had had air injected into the peritoneum were studied. The investigators found that the peritoneum covering the diaphragm is devoid of light pressure sense, but that on strong pressure with a headed point or light contact with a rough point there is an acute response of pain sense. The localization of pain from stimulation of the diaphragmatic peritoneum is never in the diaphragm itself. It is always referred to some distant part. Stimulation of the outer margin causes diffuse pain over the lower costal region and subcostal abdominal wall. Stimulation of the central portion produces *pain over a sharply limited point somewhere along the trapezius ridge*. These impulses are doubtless carried by afferent fibres of the phrenic nerve to the cervical cord and thence referred to the neck by the sensitized cutaneous nerves of the fourth cervical segment.

In the following case neck pain was a very characteristic feature. It was present with intermittent severity for perhaps a week before the drainage of the subphrenic abscess.

J. M., a boy of eight years, came home from school, October 22, 1926, with a pain in his abdomen and vomiting. An osteopath was called and he attended the child for three days until October 25, when obviously being worse, a pediatricist, Dr. C. A. Aldrich, was called, who in turn immediately summoned the writer. At this time the boy appeared to be acutely ill. The abdomen was uniformly distended, somewhat rigid, and tender. There was increased tenderness in the right lower quadrant. The temperature was 102 degrees, the pulse 120-130, and the respiration 36. The leucocyte count was 16,800. The patient was taken to the Evanston Hospital and a laparotomy performed. On opening the peritoneum a large amount of free, watery pus gushed forth. A gangrenous appendix, evidently the cause of the generalized peritonitis was removed by "ligation and drop" method. Three rubber tubes were used for drainage. The patient was immediately placed in Fowler's position and fluids were pushed.

For the first week the convalescence was fairly satisfactory, although the temperature never was less than 100 and the pulse less than 110. Beginning the seventh day the evening temperatures began to be higher each day until the twelfth day it reached 103.6°, and the pulse averaged 120-130. On this day the patient was anesthetized and the wound explored by finger and a rectal examination made. No evidence of abscess was found, however. During these days a very striking thing was the patient's more or less constant complaint of *pain in the neck*. This pain was in the right side of the neck above the clavicle. Its significance was not recognized until later. On the thirteenth day Doctor Aldrich noted an area of dullness of the right lower chest. The patient was seen by the late Dr. Albert E. Halstead on this day, who was of the opinion that there was a subdiaphragmatic abscess. The leucocyte count was 25,000. X-ray examination

AUSCULTATION IN DIAGNOSIS OF FRACTURE

was reported by Dr. E. L. Jenkinson as follows: "The right diaphragm is greatly elevated, extending upward to the third rib anteriorly. The heart is displaced to the left. The left diaphragm is normal. The elevation of the right diaphragm is probably due to a subdiaphragmatic abscess with compression of the right lung." (See Fig. 1.) On the fifteenth day (November 9, 1926), under ethylene anaesthesia, an operation for subphrenic abscess was done. A four-inch incision was made over the right tenth rib in the posterior axillary line. About $3\frac{1}{2}$ inches of the rib was resected subperiosteally. Incision was then made through the visceral pleura into the pleural cavity itself. There was no evidence of infection in the pleural cavity and the lung was retracted above this incision. The visceral pleura was now sutured to the parietal pleura which covered the dome of the diaphragm in an elliptical manner, leaving a space some $1\frac{1}{2} \times \frac{1}{2}$ inches through which to incise the diaphragm. (See Fig. 2.) The latter was then incised and 800 c.c. of foul-smelling pus poured out. Cultures of this fluid showed various organisms including Gram-negative bacilli, Gram-positive cocci in pairs and chains, and Gram-positive bacilli. The abscess cavity was cautiously explored with the finger, but no accessory pockets were located. The skin was sutured to the periosteum, in order to have less painful granulation area at dressings, and a rubber drainage tube was sutured in place. The temperature quickly subsided, but three days later an abscess over the right inguinal ring became evident. Under nitrous oxide gas this abscess was incised and 1-2 ounces of thick, creamy pus evacuated. From this time on the convalescence was uneventful. The discharge from the subphrenic abscess diminished in quantity daily. Thirty days after admission the patient was discharged from the hospital to his home in care of a nurse. He rapidly gained in weight and three weeks later the wounds were completely healed and the child was in excellent health.

FREDERICK CHRISTOPHER, M.D.,
Evanston, Ills.

BIBLIOGRAPHY

- ¹ Dexter, R.: *Amer. Jour. Med. Science*, vol. clxx, p. 810, December, 1925.
² Capps, J. A., and Coleman, G. H.: *Arch. of Int. Med.*, vol. xxx, p. 778, December, 1922.

AUSCULTATION IN DIAGNOSIS OF FRACTURE

Auscultation, so widely used in general medicine and surgery, is strikingly neglected in the differential diagnosis of fracture. It is true that the tests that may be applied in suspected cases are numerous and varied. It is true that many accident cases are so obviously fracture cases that a mere glance or short palpation is all that is required to establish the diagnosis. Yet the cases in which fracture is suspected but indeterminable without X-ray are not rare. This is especially true of those cases in which the fracture is transverse and without displacement.

It is well known that bone is an excellent conductor of sound. If one places the ear or stethoscope over one point on a bone and percusses over another, the transmitted sound is sharp, clear, and distinct. This same phenomenon occurs when the points of auscultation and percussion are covered by skin and fascia, that is, are subcutaneous.* It is also readily understood that any interruption in the continuity of the bone between the points of auscultation and percussion will cause an impairment in sound transmission. This may be verified by comparing the sound, similarly elicited, from the symmetrically located bone of the body, if desired. Advantage may therefore be taken of these facts in cases of suspected fracture by listening—

BRIEF COMMUNICATIONS

say over a condyle of the humerus while percussing the greater tubercle. Integrity or rupture of the continuity of the shaft of the humerus will then be indicated according as the sound is sharp and clear or muffled or absent.

These ideas prompted the author to attempt a study of fracture cases, using the principles and methods noted above. Results were gratifying from the start. One case, for example, was that of a woman with suspected fracture of the femur. The lady believed that she had heard something crack on falling. Diagnosis was indefinite. Auscultation, used as above, showed definite impairment of sound transmission. The note was dull—not sharp. X-ray showed a transverse fracture without displacement.†

Another case was that of a boy who had injured his leg. The nature of the accident made fracture of the fibula very possible. Point tenderness was elicited over the junction of the middle and distal thirds of this bone. No other striking signs nor symptoms of fracture were present. Diagnosis was uncertain. The auscultatory test was negative. The sounds of both tibiae were equal and of the same character and quality. X-ray failed to show presence of fracture.

In a third case there had been fracture of the tibia with various treatments and mistreatments. There was healing extending over several months with marked bowing of the extremity. Impairment of sound transmission (elicited with particular ease from this bone due to its subcutaneous location) was present. There was also present a strikingly musical quality to the sound which was very different from that obtained in similar manner from the tibia of the other limb.

It is believed that these experiences ‡ are sufficient to indicate the possibilities and usefulness of this method. X-ray is costly, requires time and trouble, and is frequently unavailable altogether. Any test then, which is simple, ready, economical, definite, and characteristic, and which may frequently serve in the place of the X-ray, should be welcome to the profession. It is hoped and believed that the procedure described herein will furnish such an additional diagnostic aid.

ALBERT S. ARKUSH, M.D.,
San Francisco, Cal.

* Clear transmission of sound across the joints of the phalanges was obtained while percussing the end of the distal phalanx.

† The test was very definite. Only a very fine fracture line was shown by the plate.

‡ Each of these cases was verified by experienced physicians.

CHANGE OF EDITORIAL ADDRESS

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